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METHODS OF MAKING FLOW TESTS AND THEIR VALUE TO WATER WORKS ENGINEERS[1]

BY GEORGE W. BOOTH[2]

About twenty years ago, the National Board of Fire Underwriters organized a corps of engineers to survey and report on the adequacy of the fire fighting facilities of the larger American cities; since that time other fire insurance organizations have undertaken similar work for the smaller towns and villages and have extended its scope to cover individual plants or risks.

It was early emphasized that pressure alone meant nothing with respect to the delivering capacity of a water system, and various attempts were made to devise a practical method of measuring fire flow available. Calculations could be made in some cases, but these became much involved in a well gridironed system, and were misleading in many instances. In some of the early tests of systems, a number of engines were connected to hydrants and operated simultaneously; this was expensive and inconvenient, and left the city poorly protected during that time. Other methods were used, such as the flow from a number of hydrants through short hose lines or the discharge of individual hydrants through a special venturi nozzle. Eventually a system of testing by groups of hydrants was evolved, and after

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

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various modifications as to methods, a scheme as outlined herein was worked out.

The equipment necessary consists of a hydrant cap tapped to take a pressure gage, four Pitot blades, four 50-pound gages, and one 100- or 200-pound gage, depending upon the static pressure on the systems.

The Pitot tube used in determining discharges from hydrant outlets has a straight blade about 4-inches long, which is threaded to permit connecting to a piece of $\frac{1}{4}$-inch brass pipe 8 or 10-inches long, on the other end of which is screwed the gage by which the velocity pressure of discharge is determined; a union may be used to keep the joints tight in whatever position the gage may be.

The gage best suited for the Pitot is a 3-inch, graduated in half pounds, from 0 to 50 pounds. Such a gage may be read easily to the nearest quarter pound; corrections should be made as indicated by calibrations before and after using, either by means of a weight tester, or by comparison with an accurate test gage.

The method of conducting the tests as practised by engineers of the National Board of Fire Underwriters is a development of the scheme of measuring discharges from smooth-bore fire department nozzles by means of a pitot tube and pressure gage, in the manner described by John R. Freeman in his "Experiments Relating to Hydraulics of Fire Streams."

It is possible to measure hydrant discharges with considerable accuracy by use of short lines of hose and large nozzles; however, in cities where the normal hydrant pressures are low, only a small part of the total quantity available for engine supply may be obtained in this way, and much more time and labor is consumed than when open butt discharges are measured. For these reasons, and in order that a representative number of tests might be made in a reasonable time in the various cities reported on by the National Board, the present scheme of measuring discharges from the open butts was worked out. It is believed that the results obtained will show not more than 5 per cent of error.

In measuring discharges directly from open butts, the orifice is often not completely filled, especially in the case of steamer outlets (4 or $4\frac{1}{2}$-inch) and the velocity of discharge is not uniform throughout the part that is filled; neither of these features is so marked in the $2\frac{1}{2}$-inch outlets and can usually be ignored in small outlets. The area of no flow is almost always a segment in the bottom of the

FIG. 1

outlet, of varying height, depending upon the design of the hydrant and somewhat upon the velocity of the stream. Any projection into the waterway such as the end of the stem of an independent valve, or a roughness of the nipple, will also produce small areas of no flow. The area of no flow is in most cases fairly well defined, and the shape of the "hole" is sufficiently uniform to enable its proportion to

TABLE 1

Discharge through circular outlets in gallons per minute for indicated velocity pressure in pounds

$$G = 29.83cd^2\sqrt{p}$$
$$C = 0.90$$

PRESSURE	DIAMETER OF OUTLET							
	$2\frac{1}{4}$ inches	$2\frac{5}{16}$ inches	$2\frac{3}{8}$ inches	$2\frac{7}{16}$ inches	$2\frac{1}{2}$ inches	$2\frac{9}{16}$ inches	$2\frac{5}{8}$ inches	$2\frac{11}{16}$ inches
pounds	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*
½	90	100	110	110	120	120	130	140
1	140	140	150	160	170	180	180	190
1½	170	180	190	200	210	220	230	240
2	190	200	210	230	240	250	260	270
2½	220	230	240	250	270	280	290	310
3	240	250	260	280	290	310	320	340
3½	250	270	280	300	310	330	350	360
4	270	290	300	320	340	350	370	390
4½	290	300	320	340	360	370	390	410
5	300	320	340	360	380	390	410	430
5½	320	340	350	370	390	410	430	450
6	330	350	370	390	410	430	450	470
6½	350	370	390	410	430	450	470	490
7	360	380	400	420	440	470	490	510
7½	370	390	410	440	460	480	510	530
8	380	410	430	450	480	500	520	550
8½	400	420	440	460	490	510	540	560
9	410	430	450	480	500	530	550	580
9½	420	440	470	490	520	540	570	600
10	430	450	480	500	530	560	580	610

the total area to be determined by measuring its height with a rule; for example, with a 4½-inch outlet, an area of no flow 1-inch high forms 10 to 12 per cent of the area of the outlet, a 1½-inch hole, 20 to 25 per cent and so on. In some cases pressure will not be sufficient to fill the nipple at the top. In such cases measurement of the depth of water flowing will suffice to determine the discharge.

In determining the average velocity of the stream issuing from the outlet, the Pitot tube is moved throughout the area, and the observer will soon train himself by this traverse to fix upon a substantially accurate average; readings noted at the center and near the ends of the horizontal and vertical diameters will usually suffice, and the center reading in a small outlet is in most cases very near the average for the entire area. Readings should not be taken closer than $\frac{1}{4}$-inch to the sides of the orifice, since there is a noticeable retardation of velocity caused by friction against the walls of the hydrant nipple. This retardation necessitates applying a coefficient of discharge, which has been determined by experiment on three different makes of hydrants with outlets of various sizes and with velocities of discharge ranging from $1\frac{1}{2}$ to 28 pounds; the discharges as measured by the Pitot tube were compared with those determined variously by Venturi meter, Pitometer and Worthington current meter. The coefficient of discharge ranged from 0.85 to 0.96 with an average of 0.91. It is therefore concluded that a coefficient of 0.90 is a fair one to use; this is applied after allowance had been made, as heretofore mentioned, in the case of outlets not completely filled by the stream.

Velocity heads of 1 pound or more are desirable since they are read with greater accuracy by the ordinary observer, and also because any inaccuracy in the gage reading has less effect on the correctness of the discharge figures. However, discharges may be determined with considerable accuracy in cases where the velocity head is as low as $\frac{1}{4}$ pound. It is better where discharges are small to use only one small outlet, rather than two small ones or a large one.

The number of hydrants in a group, the discharges from which are read simultaneously, is usually four. In exceptional cases more hydrants are opened, depending upon the quantity of water available, the pressures and the character of the district in which the test is made. It is usual to open one steamer or two hose outlets on the hydrants used. It is better not to open enough outlets to lower the pressure in the mains to a figure below that assumed to be the minimum consistent with good fire service, which will be 20 pounds where pumpers are used, or 60 to 75 pounds or more where pressures are high enough to furnish effective streams direct from hydrants. Generally if sufficient water is drawn to lower the pressure in the mains 10 to 15 pounds the test will be satisfactory. Diameters of outlets are recorded to the nearest sixteenth of an inch.

The pressure in the mains before and during the tests is determined by attaching a gage to a hydrant preferably located near the center of the group to be tested; it is sometimes advisable to have another gage at a hydrant outside the group, to determine the loss of head in the main arteries, or a recording gage located near the center of the distribution system may serve the purpose for a number of groups. Knowing the loss of head due to ordinary consumption, and the additional loss due to the measured flow from hydrants, a close approximation may be made of the quantity available at any given pressure. Care should be taken in the selection of the location of the residual hydrant, as the accuracy of the test will be affected by the location. The ideal test consists of opening a hydrant each way from the residual.

With a known drop in pressure when a known quantity of water is drawn, it is comparatively easy, by using a hydraulic slide rule, to estimate the quantity of water available at any residual pressure. This method can be used in connection with most tests, but can not be used where the assumed residual pressure would lower the hydraulic gradient below the high point of any main between the supply works and the test.

In making flow tests and in studying the results, actual conditions at time of serious fire should be taken into consideration. For that reason, tests in a system which has a small standpipe near the point of test give an erroneous result, as the main flow for the few minutes after the hydrants are open will come from the standpipe. In cases of this kind, it is best to run the test with the standpipe cut off.

Fire protection engineers making reports upon the adequacy and reliability of water systems find that flow tests are undoubtedly the most practical, economical and instructive method of studying the efficiency of a distribution system. Similar tests could be profitably used by water works engineers in designing reinforcements to a distribution system and in keeping informed of the condition of an existing system.

A carefully designed distribution system may in the course of time prove inadequate, unless the community develops in such a way that its requirements do not exceed those assumed when the system was originally designed. If the character of the community changes, the existing system may become deficient. Although the system may appear to be as efficient as when it was first installed, yet the limit, beyond which the inadequacy will soon be evident, may have

been reached. For example, in the City of Paterson, N. J., a district which was originally residential in character gradually became a factory section, but without a proper strengthening of the distribution system; in the conflagration which swept part of the city, this condition was forcibly brought out, as a number of the factories though well equipped with fire pumps, could not be saved as there was a serious shortage of water.

In order to learn the exact condition of a distribution system an investigation of the actual capacity throughout its extent should be made. Such an investigation is best made by means of flow tests and the results obtained often indicate ways in which the operation of the system can be improved. An interesting example of this occurred several years ago in Buffalo. The city is supplied in two zones, and originally the congested value district, in which are millions of dollars of value in buildings and contents, was supplied from the low pressure zone. To improve pressure, and thus make the water supply better available in the higher buildings, the zone limits were changed by opening certain valves and closing others, thus throwing some of the mains in this district into the high pressure zone. Pressures were increased, and it was believed that the desired results had been accomplished. A flow test, however, showed that, despite the increased pressure, the change resulted in only 3,300 gallons a minute being available in the heart of this district; the estimated required flow was 12,000 gallons a minute. Investigation showed that with slight changes as to closed valves and the transfer of one large main from the low service to the high, material improvement would result. These changes were carried out, after which a flow test was made, with the result that a supply of 18,000 gallons a minute was obtained, and with a considerably less pressure at the pumping station than previously.

In various other ways these tests are useful to a water works engineer. They show the effects of a known draft, which furnishes data to calculate the effect of any demand. They indicate the condition of the system with respect to obstructions, such as closed valves, acute bends, and sediment. They show the reserve capacity to meet the demands of a serious fire, results of broken feeder main, etc. They furnish data concerning the probable need of supporting mains and additional gridironing.

In general, two series of tests should be run, one on the arteries to determine their general adequacy, and the other on the minor

distributors to study local losses, including that in hydrants and hydrant branches. Where the desired flow for the district cannot be obtained on the arteries at a residual pressure considerably above 20 pounds it is obvious that at some distance from this large main the local losses will be such that the fire department will not obtain the required supply for fire engines.

In a number of instances artificial conditions have been created similar to those which would exist during some emergency operation, and tests have been run to indicate the protection then available. Several years ago, the question arose in New Orleans as to the probable result on fire protection if a 48-inch artery was broken; this condition was assumed and a series of tests run with one section of this line closed off. The results of the tests were conclusive and more convincing than any amount of calculation.

In one of our investigations, flow tests taken in the day time gave fair to good quantities of water in the mercantile district, but the fire chief was not satisfied as he had recently experienced a shortage at a night fire. A test was run at midnight, with about the same flow for about one minute after the hydrants were open, but it was noted that the residual pressure gage was still going down and continued to do so for a period of half an hour when it became stationary at 20 pounds, with a total flow from the hydrants of less than 500 gallons. The explanation was that each night the gate valve on a reservoir outlet was nearly closed, "to prevent heavy wastage in case of a break in the system during the night." The high flow on the first reading came from the storage in the pipe system on the hills; among other things this test indicates the need of keeping hydrants flowing until the residual becomes stable.

Another interesting test was on a system of a private company. We were told the system was all in one service or zone from a reservoir. Tests at various places showed very erratic results; much greater flows from one hydrant than another and either very little drop or very great drop in the residual pressure, none of which could be accounted for by size and locations of mains. When the matter was taken up with the superintendent as to the probability of closed gate valves he proudly explained his method of operation, which was to isolate various sections of the city by closing all gate valves except on one line, thus permitting him "in case of a break to shut off the district by operating only one valve."

For a number of years the water department of Brooklyn, N. Y., maintained a party which conducted flow tests whenever there was any question of adequacy of supply, and it was on the basis of the results obtained that reinforcing mains were installed. These tests were largely in manufacturing sections, where it was a question of adequacy of supply to automatic sprinklers and other fire protection equipment.

It is now a recognized practice of insurance inspection organizations, where an automatic sprinkler system receives its supply from city mains, to conduct a flow test at the nearest hydrant to the plant, and, from this, determine if the system can deliver at least 500 gallons for the smaller plants and 1,000 gallons for the larger ones, while maintaining a pressure in the mains sufficient to serve the top line of sprinklers. The Brooklyn investigation went even further, inasmuch as the flow was not considered satisfactory unless 5,000 to 10,000 gallons a minute were available at a pressure of at least 20 pounds. The ultimate result of these tests was that numerous 12-, 16- and 24-inch lines were laid through a section of distribution which previously was largely 6-inch.

Detroit recently completed tests embracing its entire system and the data obtained were used as a basis in determining the reinforcement necessary in those sections where the supply was deficient. Upon the completion of the reinforcement, tests were again made in the sections strengthened, to determine the effect of the improvement.

Baltimore pursued the same policy in the Highlandtown-Canton districts and Milwaukee is considering a similar investigation.

Chicago in 1913 made a detailed study of a section, three square miles in area, using flow tests to determine the available supply. The investigation resulted in the replacement of a mile of 4-inch pipe by larger sizes, the laying of 2½ miles of 6-, 8- and 12-inch pipe for the purpose of eliminating 18 dead ends and furnishing better supply to 28 small mains. Seventy-six small hydrants were replaced by larger hydrants, and 39 new hydrants were installed. This improvement, for which $50,000 was appropriated, resulted in increasing the supply 225 per cent.

Following are a few of the many examples of observations in mains discovered by our engineers after making flow tests.

In an Ohio city of 30,000 population, flow tests indicated that the system was not delivering its full capacity. On subsequent inves-

tigation, a closed valve was located on a 20-inch supply line which, when opened, increased the supply 290 per cent and pressures during domestic consumption 5 pounds.

In a Connecticut city of 100,000 population, a valve was found closed which, when opened, increased the flow 16 per cent and decreased the pumping head 12 pounds.

In a Michigan city of 50,000 population, where there are two mains in the main street of the principal mercantile district, flow tests showed good supply to hydrants off one main and poor supply to hydrants off the other. Subsequent investigation showed two closed valves in one of the mains and a closed valve in a cross-connection.

In a New Jersey city of 75,000 population, flow tests in one section showed 200 gallons a minute with a residual pressure of 0. After two valves, which were found closed, were opened and a cross-connection was made to a feeder, a test at the same location gave 2,080 gallons a minute, with a residual of 19 pounds.

In a Pennsylvania city of 65,000 population, a 30-inch valve on a supply line was found throttled; in a New Jersey city of 140,000 population, 6 valves were found closed; in a Rhode Island city of 60,000 population, a 20-inch valve was found closed; in a Virginia city of 150,000 population, a 16-inch valve was found closed; in a Kansas city of 50,000 population, four 12-inch valves were found closed.

These examples illustrate the advantage to operating engineers of making periodic tests at certain locations to determine whether the system is delivering its full capacity.

A thorough study of flow tests in connection with pressure observations along the feeder mains will often give interesting data on consumption and aid in waste investigation. A very decided drop in pressure on a gage located on the supply main, particularly when the flow drawn is small, is indicative either of an obstructed line or a line delivering nearly its full capacity. Such a study made of tests in a city in central New York indicated that the normal consumption was exceedingly high; as there was no meter on the line, further investigation was made of pressure at night and during the day, and at time of flow test, with gages at several points on the supply main, with the result that it was determined consumption was at a rate of over 500 gallons per capita. Subsequent waste investiga-

tion confirmed this and sufficient waste was eliminated to defer expensive further development of the water shed and an additional supply main.

One of the greatest practical benefits to be obtained from flow tests is in the object lesson furnished to the city council or other body that hold the appropriating power. A weak test near the home of a councilman, or about the factory of an influential citizen will often open the purse strings. A few years ago, a series of tests were run in a New Jersey community, where, because of very high pressures, it was believed by all concerned the supply was generally ample, as the fire department had never complained of shortage. Tests in an old section of the system, where mains were 4-inch and 6-inch, well gridironed, soon showed the inadequacy of the supply for a serious fire; the evidence was so convincing that an immediate appropriation for over 12 miles of mains was made.

THE RELATION OF FIRE PROTECTION REQUIREMENTS TO THE DISTRIBUTION SYSTEM OF SMALL TOWNS[1]

By Clarence Goldsmith[2]

In the design of the pipe distribution system of water works to supply a small town, the selection of the pipe sizes should be based upon the fire protection requirements. The rates at which water must be furnished to supply even moderately adequate fire protection far exceed those which are required for domestic consumption and the few manufacturing activities. Consideration should be given, therefore, to determining the probable fire demand.

Sections containing small dwellings of low heights occupying not more than one-third of the block front require two fire streams, or not less than 500 gallons per minute. It is true that a large proportion of fires occurring are extinguished by chemicals, small appliances, and perhaps a dash of water from a single hose line, but provision should be made to cope with a fire which has reached considerable magnitude by the time the fire company arrives. Where the buildings are sufficiently close to expose one another, i. e., with a separation of 50 feet or less, such as occurs at and near the business center, a further complication occurs, for additional streams are needed to protect the exposed building or buildings. It may be assumed, therefore, that two additional streams or four in all should be provided for even the smallest community at places where buildings are grouped.

For effective fire fighting in order to prevent the fire from spreading from building to building where the buildings are congested, the streams should be of sufficient size to penetrate the burning building and wet down those buildings which are exposed. This requires playpipes having nozzles of $1\frac{1}{8}$ to $1\frac{1}{4}$ inches in diameter and fair pressures, for a nozzle pressure of from 30 to 40 pounds is required

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

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to give an effective horizontal or vertical reach of about 60 feet It therefore appears reasonable that towns having populations of 2000 or less should have four or more fire streams of 250 to 300 gallons available, which makes a minimum requirement for fire protection of from 1000 to 1500 gallons a minute. More water is required for the protection of larger towns, and this subject has been thoroughly covered by previous papers presented to the Association.

The next step in the design of a distribution system is to provide for the concentration of the streams. The friction loss in fire hose is one of the greatest limiting features in fire fighting, and, together with the number of streams required, determines the location and spacing of the hydrants, for unless a sufficient number of hydrants are provided, the loss in the long hose lines renders an otherwise satisfactory supply ineffective. In order that there may be no unnecessary loss between the mains and the nozzle, the hydrants should be of such size and design that the losses in them are kept at the minimum. The hydrants should have a sufficient number of outlets to permit the connecting of the required number of hose lines. With the assumption that four fire streams are the minimum required for any group of buildings, it is evident that at least two hydrants should be available. Hose lines should not exceed 400 or 500 feet in length, which requires that the hydrants be not more than 300 or 400 feet from the buildings to be protected. Where direct hydrant hose streams are used, these distances should be about 100 feet less than when fire engines are available to raise the pressure. As a general proposition, there should be one hydrant at each street intersection, and intermediate hydrants should be set where the distance between street intersections exceeds 350 or 400 feet.

When the quantity of water required for fire fighting needs has been determined, a map should be prepared showing the streets; and buildings and groups of buildings to be protected should be indicated on the map. It then becomes a simple matter to place on the map the necessary hydrants to enable the number of streams required in the various parts of the town to be concentrated in a satisfactory manner. With this preliminary information available, the design of the distribution system can be approached in an intelligent manner.

Although it generally would not be economical in designing a a distribution system for a small town to provide for the protection of additional values, which would probably develop in the next

fifteen or twenty years, yet the design of a system should be made with this in view. It would not mean that the mains to be laid should be of sufficient capacity to care for these possible future demands, but the pipes now being laid should be so routed and of such capacity that while taking care of present requirements they would lend themselves to incorporation in a system which might be required twenty years hence.

The location of the source of the supply has a most important bearing on the design of the distribution system for the maximum fire demands necessarily tax any economically designed distribution system to its utmost, and, therefore, all mains laid should be located with the idea of making them available as water carriers to the points where the greatest fire demand will occur. This is usually in the center of a town, although frequently a group of manufacturing buildings or warehouses along the railroad in some other part of the town may require as much and sometimes more water than the mercantile center, although ordinarily this center is the determining factor in settling upon the capacity required. It is desirable to have the mains serving the central section enter from at least two sides in order to utilize their greatest capacity and, at the same time, secure reliability in case of accident. It is seen, therefore, that the most ideal layout is to have a pumping station on one side of the city and elevated storage on the other side, provided the topography is such that a sufficient elevation is available for a reservoir. Standpipe storage is seldom of any value in an extended fire, but such storage is often economic from the operating standpoint, as it permits the shutting down of the pumps in small plants during the night and also can furnish the fire demand for the short period required to get additional boilers, pumps, or other equipment into service in case of a large fire. It is always desirable to have the capacity of the elevated storage sufficient to equal or nearly equal the fire demand for a five-hour period.

When the location of the source of supply has been determined and it has been decided whether the fire supply could be best supplied from elevated storage, it is then necessary to determine whether dependence for fire fighting will be placed on the pressures carried in the mains or on fire engines. Effective fire streams require that pressures be maintained at the time of fire flow at about 60 pounds at the hydrant, although where buildings are low and scattered, this pressure may be reduced to 50 pounds. In order to maintain this

pressure for direct hydrant hose streams, the amount of pressure which can be lost by friction in the distribution system is necessarily very small. Where fire engines are used they can secure an adequate supply of water if the pressure at the hydrant is reduced to about 20 pounds, and in some cases where the mains are of ample size and low pressures are carried, due to low elevation of reservoir, pressures lower than this are capable of furnishing a satisfactory supply, but it is advisable to have 20 pounds available to overcome the friction loss in the hydrant branch, hydrant, and suction hose. In direct pumping systems it is practicable to carry fire pressure up to 100 pounds. When it has been determined what pressure is to be carried, either by the elevation of the reservoir or the elevation of the supply works, and the pressure to be carried at the pumping station, it is an easy matter to calculate the total permissible drop in pressure in the mains, due to friction, in order to furnish either 60 pounds or 20 pounds at any point in the system.

In order that the discussion may be confined as closely as possible to distribution systems, it will be assumed that the pumping station is located fairly close to the center of the town or that the supply main is of sufficient size to deliver ordinary consumption demands with only a few pounds drop in pressure. This is a reasonable assumption as the fire demands far exceed the consumption demand in smaller towns.

A study of the street map should now be made in order to select the most direct routes from the supply works to the point of greatest demand so that unnecessary friction losses will not be built up by following circuitous routes. At the same time consideration must be given to the protection of buildings between the pumping station and the center of the town. It is advisable to select certain streets through which additional mains may be laid in the future to meet the increased demands due to growth. After the locations of the through mains have been determined, the best method of connecting them and the best method of tying them together by mains of sufficient size to deliver the required capacity where it is needed should be considered. When this has been done, the next step is to provide mains to supply the other sections which it has been decided to serve. Mains extending into these sections should be looped, if possible, so that more adequate and reliable supply may be available from the hydrants than if they were supplied from dead ends, for friction losses are much less when equal quantities of water are being drawn from a looped line.

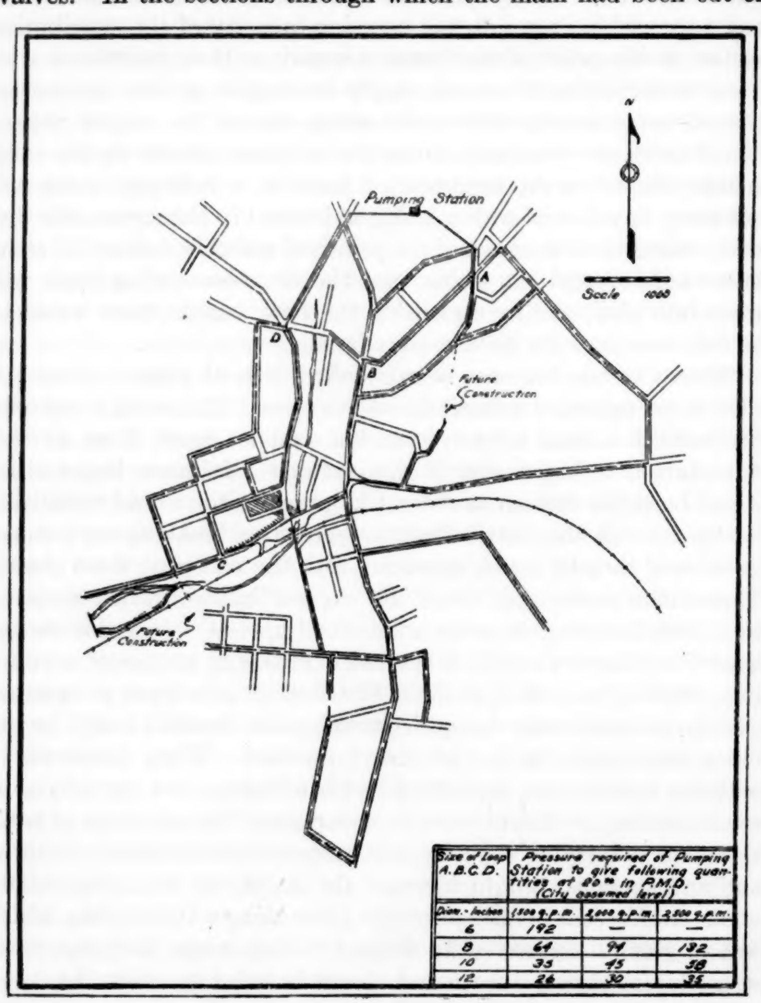
In making the preliminary design it will be found advisable to provide a fairly extensive system, and if estimates show that its cost will exceed the funds available, it will be possible to eliminate the immediate installation of mains in some of the streets by re-routing some of the lines and setting a second hydrant at some street intersections. When the growth of the city requires additional protection, in certain sections, the laying of mains in the streets originally left vacant will sufficiently reinforce the distribution system to meet the increased demands. In making this study, however, decreasing the sizes of mains for economic purposes should not be considered. It will probably be found necessary to furnish domestic consumption in some of the streets not served by the large mains which are originally installed, but this can be taken care of by laying service pipes of sufficient size to the premises of the consumer. One- and two-inch pipe will generally be found adequate for this service. By adopting this method it will be unnecessary to trench entirely through each street, and thus money can be saved. In the end this method is preferable to laying 4-inch mains, for they are not considered suitable for fire service. Friction loss in pipe of this size is 3 pounds per 100 feet for a flow of 250 gallons, and twelve pounds for 500 gallons. It is theoretically possibly to use short lines of 4-inch pipe for supplying one intermediate hydrant, but the actual saving in cost in using this small size pipe over using 6-inch pipe is not sufficient to justify its use, particularly as the capacities of modern fire engines range from 300 to 1000 gallons per minute, and average about 700 gallons. For the same resason it is undesirable to use 4-inch pipe for hydrant branches. Excellent fire protection in smaller places can be furnished by 6-inch pipe when looped or forming part of a gridiron system; however, when dead end lines exceed 800 feet in length, and it does not seem probable that they can be looped or connected for sometime, it is economical to use 8-inch pipe.

In laying out any distribution system the idea should not be lost sight of that it may be necessary to cut out any line at sometime in order to make repairs or connect into some extension. It is, therefore, essential in order to furnish reliable fire protection that two or more lines be laid in preference to a single line of equal carrying capacity. From pumping stations the mains should extend along two or more different routes and ultimately meet at or near the place of greatest demand. It is often desirable to lay mains cross-connect-

ing the principal feeders or force mains from the pumping station in order to provide local fire protection and domestic consumption, but it should be remembered that these mains do not contribute in any appreciable degree to the carrying capacity of the distribution system to the point of maximum demand, as their function is confined to furnishing the local supply or to give greater concentration at some intermediate point along one of the supply mains, i.e., if there are two mains from the pumping station to the mercantile district, a cross-connecting main at a half-way point will not carry any flow of water during a demand in the mercantile district, unless the size of one of the principal mains is changed at some intermediate point, in which case the cross-connecting main will come into play, and by equalizing the flow, enable more water to be delivered into the district considered.

When a system has once been installed, it is of prime importance that it be operated with all the valves open. This point is not only pertinent in a small town system, but assumes equal, if not greater importance, in larger distribution systems. In some larger cities it has been the custom to extend large mains for considerable distances through the distribution system without making any connections, or if they be made, operating with the valves on them closed. These mains are termed "trunk" or "express" mains, and are operated to deliver into remote areas under the impression thst this means a more satisfactory supply is assured. This is an erroneous assumption, for it is evident that if the distribution is so weak as to cause excessive losses under domestic consumption demand it will be entirely inadequate to furnish fire protection. When pressures in outlying sections are depleted to such a degree that the service is unsatisfactory, it should serve as a warning of the necessity of additional main carrying capacity, not only to deliver water into these outlying sections, but to increase the supply to the intermediate area. In a recent investigation the gates along a 16-inch line, which was originally connected to 6- and 8-inch minor distributors at street intersections, were found closed in order to make the large main serve as a trunk feeder into a district where pressures were depleted during periods of maximum consumption. Although the static pressure in the section served by this trunk line had been raised a few pounds, flow tests indicated that the fire protection available in the section had not been increased because at the time of fire draft dependence had to be placed on the 16-inch main and the carry-

ing capacity of the intermediate mains of the distribution system could not contribute to carry the fire flow on account of the closed valves. In the sections through which the main had been cut off

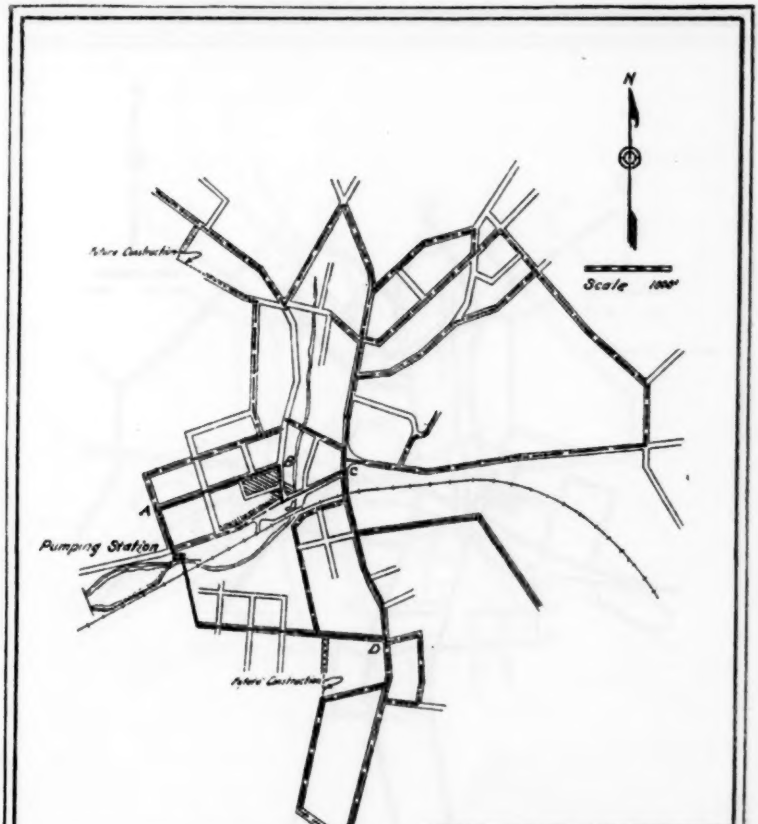


Size of Loop A.B.C.D.	Pressure required of Pumping Station to give following quantities at 20# in P.M.D. (City assumed level)		
Diam.-Inches	1500 g.p.m.	2,000 g.p.m.	2,500 g.p.m.
6	192	—	—
8	64	94	132
10	35	45	58
12	26	30	35

FIG. 1

from the distribution system by closing the valves, the available quantities for fire protection had been reduced to less than one-fourth those previously available, and with four hydrants open none could deliver 500 gallons a minute.

In many systems it appears to have been the opinion of the engineers installing large mains leading from the pumping station that it was unnecessary to connect all of them to the intersecting mains

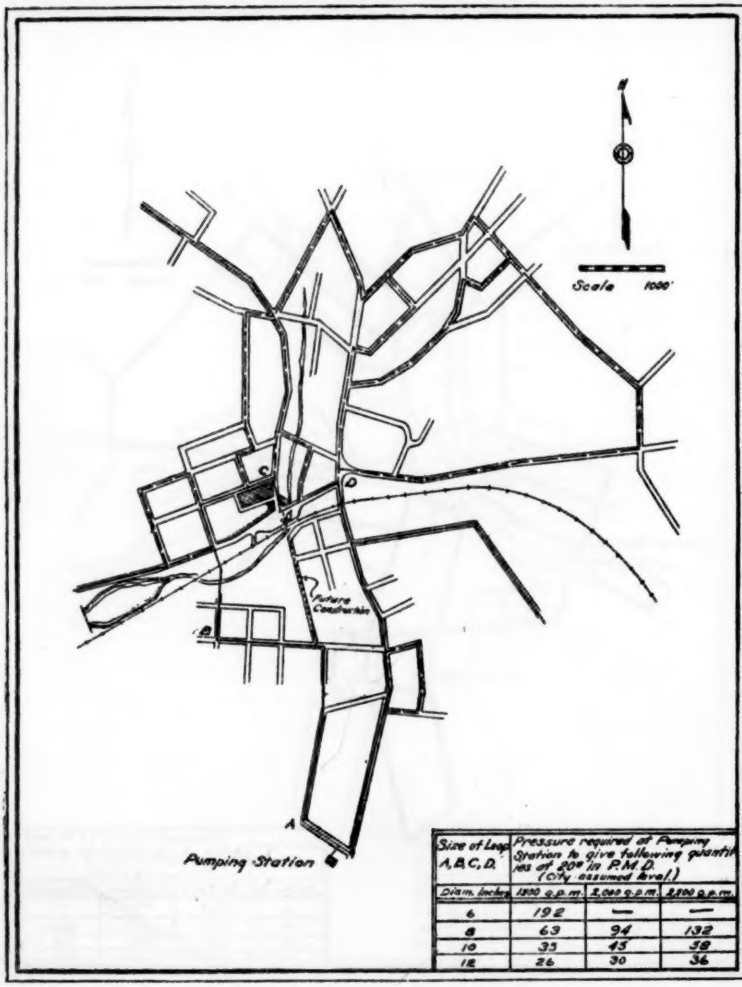


Size of Loop A.B.C.D.	Pressure required at Pumping Station to give following quantities at 20# in P.M.D. (City assumed level)		
Diam.-inch	1500 g.p.m.	2000 g.p.m.	2500 g.p.m.
6	124	—	—
8	45	64	86
10	29	35	42
12	23	26	29

FIG. 2

of the distribution system. This may be true where these supply lines extend along the same or adjacent streets, but where they follow fairly well separated routes, it is obvious that these mains should be connected so as to feed the territory through which they

pass. Frequently the argument is advanced that the cost of the specials and additional gate valves necessary to make these connections is not warranted, and the reliability of these important lines

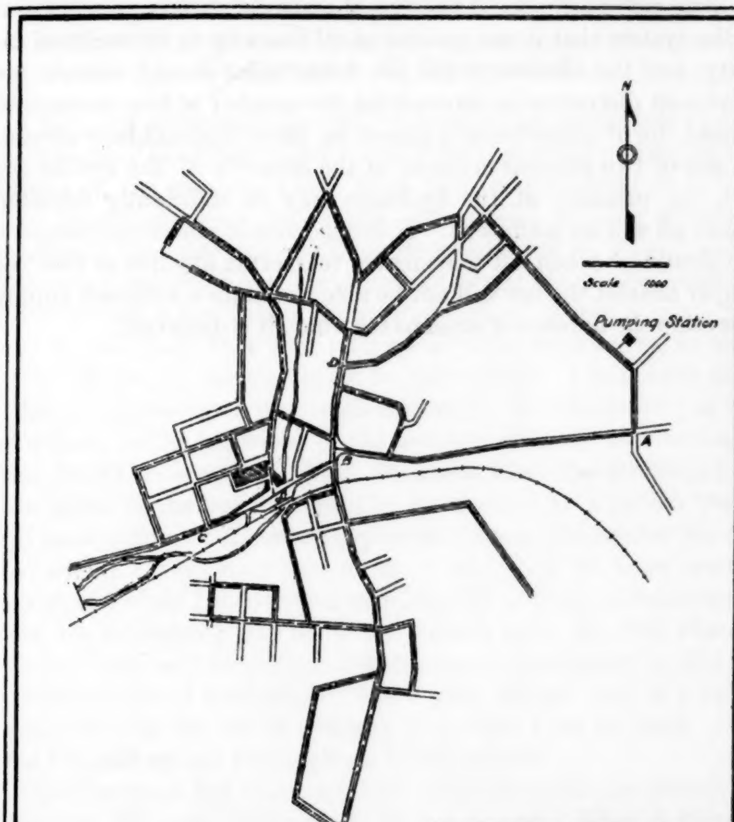


Size of Loop A, B, C, D.	Pressure required at Pumping Station to give following quantities of 20# in P.M.D. (City assumed level.)		
Diam. Inches	1500 g.p.m.	2,000 g.p.m.	2500 g.p.m.
6	192	—	—
8	63	94	132
10	35	45	58
12	26	30	36

FIG. 3

is menaced by the large number of connections. It is not necessary to connect each intersecting main with a large main, but all lines 8 inches and larger in diameter should be connected and those 6-inch mains which are not cross-connected within several blocks of

a large main. The best and most reliable method of connecting large mains with the minor distributors is by means of a run-around connection. These connections can be made between existing pipes by the use of tapping machines.



Size of Loop A.B.C.D.	Pressure required at Pumping Station to give following quantities of 20# in P.M.D. (City assumed level)		
Diam. Inches	1500 g.p.m.	2,000 g.p.m.	2,500 g.p.m.
6	235	—	—
8	73	110	155
10	38	31	67
12	28	33	40

FIG. 4

Four sketches have been prepared showing the possible design of distribution systems, with decidedly different street layouts, which will furnish adequate fire protection in towns having popula-

tions of from 1000 to 1500. The design and installations of water systems of this character are generally carried out by consulting engineers, and when they are completed, they are turned over to the town authorities for operation. Those to whom this responsibility has been entrusted should exercise the utmost care in so maintaining the system that it can operate at all times up to its designed capacity, and the officials of the fire department should always use the utmost discretion in determining the number of hose streams to be used, for if dependence is placed on direct hydrant hose streams and one or two streams in excess of the capacity of the system are used, the pressure at the hydrants may be sufficiently depleted so that all will be inefficient. If dependence is placed on pumpers, care should be taken not to endeavor to overtax any line so that the pumper nearest the fire will not be able to obtain a sufficient supply to develop the number of streams for which it is designed.

THE ECONOMIC SIGNIFICANCE OF FIRE WASTE[1]

By Franklin H. Wentworth[2]

I have not appeared before on the program or participated in the discussions of these meetings for I have felt that I had nothing to contribute on the subjects which have been under discussion. I feel very deeply, however, respecting the subject of this afternoon. In making the departure which has been indicated by your President and your President Elect, the American Water Works Association is entering upon a new field of its accountability. There is much that may be said respecting your relation as water works men, as water works officials, to the problem of fire prevention. I have been asked today to impress upon you another relation, the relation of you men as citizens to the fire waste of the country, which is now averaging $500,000,000 every year. Your President Elect has challenged my admiration in the last five years by his attitude as a citizen toward this most serious of American problems. Some philosopher has said that we are always surer that we see a star when we know another sees it; and when I encounter a man like Mr. Jordan, with his experience, his intelligence and his broad outlook upon life, and when he sees as clearly as I do the impoverishment of the country by this tremendous drain of $500,000,000 every year, 80 per cent of which is preventable by the use of ordinary care, then I am so much surer that I myself am not seeing ghosts in this matter.

The European fire waste averages about 33 cents per person; the American fire waste averages $5.00 per person. What is there in Americans as a people, what is there in our industrial, our social, our economic life, that contents us as reasonable human beings to contemplate year after year for decades such a shameful waste as this? It is partly due to our building operations of the past. Any people, any individuals, born to affluence and luxury will be easy spenders, and we Americans have been born and bred in the notion that our

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] Secretary, National Fire Protection Association, Boston, Mass.

supply of natural resources was unlimited. Our supply of lumber did obviously once seem unlimited; when our fathers settled this New England coast, they had to cut down and burn beautiful standing pine in order to get at the soil to cultivate it, and that bred in them, and it has continued in us, the notion that our supply of lumber, at any rate, was inexhaustible; and so it has seemed easier and more natural for us to build and burn and build again than to adopt those methods of building long since adopted by the more prudent countries in Europe. Perhaps in the earlier days before the locations of our cities were permanently settled, there might have been something justifiable in the unstable building carried on in America, but now that our cities are located, now that the great avenues of commerce have been laid out and we know how our country is proceeding in its development, we have no longer an excuse for the shoddy building that has been so common among us.

But there is a more subtle point to consider in this discussion, and that is that this supply of building material, the unlimited resources in this country, has affected us psychologically. We do not realize that we have a mental attitude toward the fire waste that is wholly indefensible; that is an ignorant and stupid attitude. You will find men with all the marks of human intelligence reading a fire report. They glance down the column to see if the property is insured. If they find it is insured, they dismiss the matter from their minds as something that does not affect them. If the fire insurance companies received their revenues from Mars or Jupiter or some remote planet, we might afford to assume this indifferent attitude, but they have no way of getting their revenue except by assessing it right back upon you and me. It is perfectly obvious that they must collect enough to pay for this tremendous loss and that they must collect enough to keep their offices and agencies operating as going concerns. That is clear enough to the person who thinks at all about this question and yet the notion that is prevalent in America is that this fire waste does not affect us individually. What a pitifully ignorant point of view! The minute we look at the problem, as we look at other problems that affect our lives, we see at once that all these stocks of goods in New York, in Boston, in Philadelphia or in San Francisco are insured, the buildings which house them are insured, and that insurance is added to the cost of the goods, and when you buy a hat or a suit of clothes or a pair of shoes or anything which goes through the channel of production, distribution and exchange, we pay that fire tax, we pay

the cost of that tax merged with the cost of the goods, and in most of the things we use and consume there is a cumulative tax. Take cotton, for example. Cotton is insured in the sheds of the South; it is insured on the railway platform; it is insured in transportation; it is insured in the warehouse; it is insured in the textile mill or factory; it is insured in the department store or dry goods store; all the way along from the cotton field, that cotton bears a cumulative fire tax, and when we buy a bit of cotton goods we pay that tax merged with the cost of the goods. And so with leather, so with shoes. It is so with every commodity that is manufactured: the tax must be paid because the fire waste must be compensated for. Now it is that form of indirect taxation which puzzles the minds of our people and makes them so indifferent toward this problem. A $100,000 fire in Europe shocks Europe; all the continental newspapers comment upon it and want to know how it occurred, whether the conditions which gave rise to that fire could be duplicated in other cities. A $100,000 fire in Europe shocks Europe, but if we pick up a morning paper and do not find two or three $100,000 fires, or greater, recorded in it, we think it has been a dull evening. Now we must address ourselves to this problem and realize that it is the people themselves, it is you and I that are responsible for the careless habits which cause this most colossal waste.

Indirect taxation by which the fire waste is paid for is the most subtle kind of taxation. You remember what the French physiocrats, those great Frenchmen who tried to save the head of Louis XVI from the block when the people of France were eating grass in the parks, called indirect taxation: "The method of getting the most feathers with the least squawking." You can pluck people who do not understand the subtleties of taxation by indirect taxation; by putting the tax upon their food. They cry out against the high cost of living, the struggle to live, but they do not see the cause of it; they do not see how carefully the cost of living may be loaded by a system of taxation. That is why indirect taxation is "crooked taxation," it does not stay where it is put, it is passed on, it is shifted. If you pay an income tax or a real estate tax, you draw your check for it, you undergo the physical operation of being separated from your money, but a tax that merges with the cost of everything you eat, drink and wear you do not feel in its incidence. That is why the political scientists call it "crooked" taxation, that is why all tariff taxes are a form of manslaughter. Every indirect tax is evasive and

is unjustifiable because it confuses the minds of the people. Now, the problem is, how, are we to make our people conscious of this fire waste and its economic significance? Advertise a fire prevention meeting in the Manhattan Opera House here in New York for tomorrow night, and how many people would be in the audience? Half a dozen perhaps, no matter how much you advertised it. Fire prevention is too remote from the consciousness of our people. They think it is a fire insurance problem and leave it to the fire insurance companies, who are helpless against the effects of such ignorance. What can the fire insurance companies do except to collect enough to pay this loss? Our merchants must be compensated for fire losses; we want the insurance companies to be solvent, they must be solvent; we operate State Departments to see that they remain solvent, and to remain solvent they must collect enough to pay this stupendous loss of $500,000,000 a year and to carry on their business, else capital would flow out of fire insurance and we could not get the coverage our merchants need. I am not speaking for the underwriters; I am not an underwriter; the underwriters are capable men and can speak for themselves. I am merely showing you how the problem looks after studying it for awhile. How are we to reach the American people in their present state of mind? They are in a confusing backwash of the great war, careless, with all the old faiths crumbling, with nothing really to tie to. We are living in a jazz age, a motion picture age. In Boston, where I live, we used to have in our newspapers a pictorial supplement once a week; now we have them every day; our people cannot follow the news without pictures. It will be only by the grace of God if, in another generation, we do not forget how to read, even in Massachusetts! And we are obsessed by ideas of speed. What is the idea of youth today,—in a motor car? To get somewhere, where we are not, just as soon as possible; and when we get there, what? Come back again at 40 miles an hour! When we are confronted by a psychology like that; when we have a truth to force into the consciousness of our people and find this impossibility of fixing the attention upon any reflective subject. It is not an encouraging job for a man who wants his life to count for something. We used to think that all we had to do was to point out to the newspapers the profound economic significance of this problem, send out a few men to make speeches about it and the thing would solve itself, we Americans being the alert and careful and sensible people we are.

There are methods of legal persuasion and one of them is gaining headway in this country. If in France you should have had a fire and it got outside your premises and damaged your neighbor's property, you would have to pay your neighbor's loss. That is very educative. In some of the cities of Germany, the first person who calls to offer his condolence after you have a fire is the policeman, who locks you up, and you go before a jury next day and have to prove that there is no way in which you might have prevented that fire. If you cannot prove it, you have to bear the loss yourself and pay the city for the luxury of the unnecessary use of the fire department. That seems tremendously radical to the minds of our heedless citizens and yet do you know that idea is gaining ground in America? Pennsylvania a few years ago passed a State law that in cities of the second class, if a man disobeys a fire prevention order, he shall be liable in a suit by the city for the cost of extinguishing the fire. In certain cities of the West they have not waited for State laws. Cincinnati, Cleveland, Portland, Oregon, Austin, Texas, Newark. N. J., and a lot of cities scattered over the United States have embodied that idea in a local ordinance. In Cleveland if you get a clean-up order or an order for a fire door or anything of that sort from the fire department you will find on the back of the order a copy of this ordinance, and if you do not comply you are liable to the city in a suit; and even in the charter of the city of greater New York there is such a provision. How it got in there, no one knows, but when this charter of greater New York was drawn, someone wrote that provision into it; and there it lay all those years until Mayor Mitchell came in. Mayor Mitchell had a chief of his fire prevention bureau named Adamson, from Atlanta, Ga. Mr. Adamson did the unheard of thing for an American city official, he read the charter of the city he was going to serve, and he detected this provision in the charter. He watched the fires for a few weeks, and he found that a cemetery company down in lower Manhattan had a fire in a four or five story building full of caskets and excelsior and stuff that made a bad fire. It was expensive to extinguish and took lots of water; some of the firemen were hurt and some were overcome by smoke and were sent to the hospital, and it cost the city about $2500 or $3000 to extinguish that fire. Mr. Adamson found that about two years before the company had received an order to install automatic sprinklers in their building and he went to the company and showed them their liability. Did they offer to pay? No, they argued the matter. They said "Why should we pay for the

expense of extinguishing this fire? We did not set the fire; it was an act of God. We pay our taxes to support the New York Fire Department, why should we be assessed to pay for this fire?" The Commissioner said "Here is a provision of the charter, here is a copy of the order that was given by our department to you two years ago, and here are the results of the fire. You are clearly liable." They refused to admit their liability; the Commissioner brought suit, and the lower court, showing the psychology of our Americans, threw the case out. The Commissioner lost his suit, in spite of that clear evidence, through sympathy. We regard the man who has a fire,—no matter if his carelessness is responsible for it,—we regard that man with sympathy instead of accusing him from the European point of view as a public offender. But the commissioner was bound he would win his case if possible. So he took it to the Superior Court, and the Superior Court, being made up of superior men, as they sometimes are, reversed the decision of the lower court and gave the Commissioner damages. He compromised the suit for about $1500 and the cemetery company paid it. A week or two after that a film corporation had a fire; they found that they too had had an order six months before, and their manager went down to City Hall and said "How much is it, please?" I believe the amount was $750.

That is the individual liability point of view; we can force the individual to give attention to this matter by law, but it is so slow and the educational opportunities are so limited. Now we come to what you yourselves can do. What has Mr. Jorden done in Indianapolis? Each community has, or may have, the knowledge of how to prevent fires, how to extinguish fires, all the engineering knowledge from such men as Clarence Goldsmith and George Booth and others of that type. Having that knowledge, the question is how can it be applied? It can be applied by local committees; by cooperative efforts between the water companies and the fire chiefs and all the intelligent citizens of a town who see the terrible significance of this waste and are willing to do their share in its abatement. That is what is going on in Indianapolis, under an organization which Mr. Jordan as water works official and as Chairman of the Fire Prevention Committee of the Chamber of Commerce, with his circle of friends and acquaintances, has created. That is the work which I believe will be projected by the new fire prevention section of this Association; and it will be not wholly a public service, but a service to the water companies as well, because never is there a big fire that reservoirs may not be emptied,

that unnecessary drains may not be made upon the water companies, that new problems may not present themselves. While fire prevention presents problems with which the gentlemen of the American Water Works Association are intimately acquainted, yet out of a larger consideration of their significance may come wonderful possibilities of good citizenship, larger views of our responsibilities as citizens. It is a big job for big men to keep this country from a continued impoverishment which no country, no matter what its resources, can stand.

DISCUSSION OF FIRE PROTECTION REQUIREMENTS IN DISTRIBUTION SYSTEM DESIGN[1]

Mr. J. H. Howland:[2] As an engineer of the National Board of Fire Underwriters, it was my privilege and pleasure to work with Mr. Siems and his associates in making the studies of Highlandtown, Canton District, which I think I am safe in saying the great bulk of the matter in the paper[3] by Messrs. Siems and Biser was based upon. I think it is evident if one reads that paper and digests it, that in its preparation there was very careful study and a comprehensive knowledge of the subject. To me the paper has particular merit due to the fact that it points the way to a painstaking analysis of the varying conditions existing in different sections of our large cities. By the way, such an analysis is made in comparatively few cities in this country. I only know of those mentioned by Mr. Booth in his paper; Detroit, Chicago, Baltimore, and now I think Milwaukee is about to make such a study. Second, perhaps, in importance is the fact that it furnishes us with an excellent basis for a much more extensive study relative to the controlling factors in fire protection and fire extinguishment. It has been found true from years of experience that in most of our larger cities, at least, the size and general character of the congested value district, that is, the business and mercantile center, varies in fairly direct proportion with the population. The National Board of Fire Underwriters for many years has been using a formula giving the quantities required for reasonably good fire protection in which the population has been and is now the only variable factor; and I think that we are still to be convinced of the fact that the factors of area, height, combustibility, fire pump capacity and exposure hazards in the relative weights assigned to those factors in Mr. Siems' paper give any better results in the congested value districts of most

[1] Presented before the Fire Protection Division, New York Convention, May 20, 1924.

[2] National Board of Fire Underwriters, New York, N. Y.

[3] See Journal, January, 1924, page 17.

of our large cities than that very meagre formula which we have been using for so many years. I do not mean to say by that the factors which Messrs. Siems and Biser have introduced in this method are not more direct and have not more distinctly to do with this question of fire protection and prevention, because I think we must all concede that they do, but I do think, as I am going to show you in just a minute, there is some opportunity for further study and perhaps some modification of the relative weights given to those different factors.

Siems and Biser bring in as their first factor, that of area. Any fire chief of any generalship in our large cities will tell you that the fire area is the greatest factor in the control and extinguishment of fire. It sometimes occurs through unprotected vertical openings, and if fire spreads from floor to floor, that is the same thing, it involves an area built up on stilts rather than a horizontal area, and perhaps the former will spread more rapidly, but the area is unquestionably one of the biggest factors having to do with fire protection and fire extinguishment and I think any formula that is going to be used and generally accepted will ultimately embody this factor of areas.

They next bring in the factor of height, and as one of the previous speakers has said, when we get up above six stories, it is not a question of water and fire apparatus, we have got to handle it through house pumps and steps up into these higher buildings, so that up to six stories in height the effect upon fire departments and water supplies is very marked. In other words, you can control a fire in a one-story building much easier and with less water than you can in a six-story building, partly because of the unprotected vertical openings that I just mentioned, affording an opportunity for a fire to pass from the first story up into the second; it means larger areas and perhaps a harder matter to control. In other words, we recognize that these factors that have been embodied in the method suggested by Siems and Biser are worthy of very careful consideration and much more extensive study.

Now it was the endeavor of Siems and Biser to make this method applicable to great and small structures in both large and small cities; so we applied his method or selected at random nine widely scattered towns; three each of five, ten and fifteen thousand population, respectively, and the results obtained in applying their method showed that the required quantities for the smaller average areas in those congested or small mercantile, principally mercantile districts in

those smaller towns, compared very favorably indeed with the quantities required by our meager formula, in which population was the only variable factor. When we come into the larger areas, to take care of those exceptionally large buildings in those districts, we found that the Siems and Biser method resulted in very much greater quantities than in the average area. I might mention Riverside, California, as a special example. Those of you who have been there remember the Mission Inn. That is a very large fire area, about 9500 square feet. They also have a building known as the General Wood Garage, almost of equal area, right in the heart of that mercantile center. If you apply the Siems and Biser formula to those excessively large areas, you will find that for Riverside, a population of 20,000, we require them to provide 9500 to 10,000 gallons of water. I think you will all agree that it is hardly reasonable to expect a city of that size to provide any such quantity of water. If you take the average area of the buildings, the average fire area of the buildings in the Riverside mercantile district, you will arrive at about 12,000 square feet. There again the Siems and Biser method will require 6200 gallons, where our formula will require about 4200; so that in looking over all of these nine cities selected, it is very apparent that to make this method fit in with reasonable requirements, to the smaller cities particularly, it means that we have got to allow for area in particular, a less rate of increase than the average increase. I think that is one of the principal points I want to bring out. That justifies a great deal more extensive study and will undoubtedly result in a modification of their formula.

The second and third factors to which they refer, that is the allowances for excess fire pump capacity and for combustibility, are, in my opinion, as we have tried them out, closely approximate to what they should be. I do not think there will be any very great changes in those factors. I have come to the conclusion that the exposure factor should be modified whereby a proportionately smaller allowance will be made for the larger areas again. We find in application that the Siems and Biser formula affects the required fire flow for a thousand square feet in area, 2 per cent. If you apply it to a 15,000 square foot area, it affects it 30 per cent. Now just a suggestion, I have added one fire stream, 250 gallons, to his formula and given it as a larger denominator. It reads 250 plus Y square over 60,000, where the Siems and Biser was Y square over 50,000. You will find if you apply that to the different areas that it affects all the

quantities required for all those different areas about 25 to 27 per cent, a more uniform effect upon the different conditions. I might also say that I think their assumption that a building exposed on two sides is as bad as when exposed on four is logical and sound unless the wind is blowing in all directions, which certainly does not take place immediately. I do not know of any bad fires where I have seen a hard fight put up where they were fighting on more than two sides of a building involved.

Then the last matter I want to speak of is that we all recognize that the spacing of hydrants, which has been referred to by Mr. Goldsmith, certainly has to do with the ability to utilize the supply furnished or available from a distribution system. That has not been embodied in the formula suggested by Siems and Biser. I am inclined to think that any complete formula will embody that factor of hydrant distribution. Now in closing, I will say that I think perhaps the best guide to a further study of this paper is to go carefully into the past experiences which our organization has had quite an opportunity to follow up and keep in touch with, and after once determining the fair approximate quantities for reasonable fire protection, it becomes simply a matter of apportioning to the several factors, which admittedly are part of this fire protection and extinguishing problem, the proper relative values.

Mr. V. B. Siems:[4] The only thing I want to add is that we went into the industrial section of Baltimore and made very thorough surveys by the flow test and the like, and in no place could we find anywhere where the water consumption of such a big plant as the American Sugar Refining Company, for instance, exceeded the fire protection requirements. We did that over all the industrial territory, and we also did it in the other zones of the city.

Mr. Wm. Luscombe:[5] Mention was made in Mr. Booth's paper of the operation of gate valves. I understand it is a common occurrence for engineers, who are employed to make an investigation of waterworks properties to find gate valves in a distribution system closed that are supposed to be open and I believe those of us who are charged with the operation and management of waterworks utilities should certainly pay more attention to such matters and to make frequent,

[4] Water Engineer, Baltimore, Md.
[5] Vice-President, Gary Heat, Light and Water Co., Gary, Ind.

systematic and thorough inspections of all gate valves in the distribution system to make sure they are open as they should be. We may have pumps of ample capacity, oversized mains, and all that sort of thing, but all calculations of a city's fire fighting ability may be greatly upset and heavy damages unnecessarily result when, in the case of an extensive fire, the water pressure is seriously impaired because a gate valve was unintentionally left closed. I believe a special loose leaf book, or card index, containing a record of individual important valves would be of much value, showing their location, dates tested, condition found, inspector's name, etc.

RELATIVE ECONOMY OF STANDBY OIL ENGINES[1]

By W. S. Lea[2]

While there are other methods of arrangement, the auxiliary equipment, as far as the estimates in this paper are concerned, is supposed to be installed as follows:

Gasoline engine prime movers, direct connected to centrifugal pumps, and loaded to 75 per cent of their maximum rating at 1200 r.p.m.

When oil engines, either Diesel or semi-Diesel are the prime movers, two cases are considered, viz.: (*a*) engine driving a centrifugal pump through a double helical gear, and (*b*) engine direct connected to a 25 cycle generator with direct connected exciter. The Diesel engines referred to in this paper are of the four cycle, air injection, trunk piston type.

Estimates have been prepared of the capital costs of auxiliary plants, consisting of two or more units where gasoline engines are considered, and of both one and two units where oil engines are the prime movers.

No reserve capacity is provided for in the engine installation. The engine capacity is based on the efficiencies given below for the equipment which it directly or indirectly drives. Pumps from 65 to 77 per cent; gears, 97 per cent; motors and generators combined, 80 per cent.

Where the auxiliary equipment is in the form of engine driven-pumps, there is an item of expense for piping, which does not occur in the cost of installing engine driven generators. But this is at least in part compensated for, by reason of the fact that when pumps are included in the auxiliary equipment, it is permissible to dispense with a standby unit in the motor driven plant.

In preparing estimates of the capital costs of the auxiliary plants which are of different types and capacities, the method followed was

[1] Abstract of paper read at Canadian Section meeting. Complete article in Canadian Engineer of March 4, 1924.

[2] Consulting Engineer, Montreal, Canada.

to select pumping capacities which would fully load the engines in the sizes available, and plot the plant costs so found against the pumping capacities.

Although each plant is thereby put on the same basis as far as the cost of the most expensive item in it is concerned, other factors entering into the calculations interfere with a fair comparison. For instance, manufacturers adopt certain standards in the way of pump casings, gear boxes, machine frames, etc., which are fitted with motors or running elements of a wide range in capacity. Consequently the price quoted on a machine will appear high or low according as the capacity specified happens to require a casing or frame at its lowest or highest rating.

Moreover, in the more common commercial sizes, the price of a machine on a horse power basis, as a rule falls as the power rises. But a change in price does not follow every change in the rating; it occurs in steps. The Diesel builder, for instance, may lower his price for engines over 100 b.h.p.; the semi-Diesel for engines over 125 b.h.p. In such a case a different conclusion with respect to the relative economy of Diesel and semi-Diesel engine plants, would be drawn from an estimate of a 125 h.p. than from an estimate of a 150 h.p. installation.

In order to eliminate, or at least minimize, the influence of factors of this kind, estimates of each type of auxiliary equipment considered, were prepared for several different capacities, and plotted as mentioned above. It is believed that estimates so prepared afford a fair comparison of capital costs, although it is true that the cost given for a particular capacity, may be found higher or lower than such a plant could actually be built for at current quotations.

The gasoline engine driven plants are of course cheaper than the oil engine installations, but here again the difference is much less than it was a year or two ago.

Auxiliary plants in the form of oil engine driven generators cost roughly 10 per cent more than the oil engine driven pump installations.

The annual interest, depreciation, and maintenance charges have been lumped as a percentage on the total investment; 11 per cent for gasoline engine driven plants; and 10 per cent for oil engine driven plants.

It is presumed that the attendants in the motor driven plant will look after the auxiliary equipment, and with labor eliminated, the

operating charges are confined to the cost of gasoline, fuel and lubricating oils. Fuel oil is taken at 10, gasoline 30 and lubricating oil at 100 cents per gallon, respectively.

The fuel consumption for the 6, 8 and 10 million g.p.d. plants is based on 10 h.p. hours per gallon for gasoline engines, 14 for semi-Diesel, and 17 for Diesel Engines. The work done per gallon of fuel is taken as 5 per cent less than this for the 4,000,000 g.p.d. plants and 10 per cent less for the 2,000,000 g.p.d. plants.

It is assumed that a gallon of lubricating oil is good for 3,000 h.p. hours in Diesel engines and for 1,000 h.p. hours in semi-Diesel and gasoline engines.

Where the electrical power supply to the pumping station is but rarely interrupted, and the auxiliary plant is put into commission only in the event of such a contingency, the annual cost of the plant is largely the fixed charges. For such a service the gasoline engine drive is in a class by itself, so far as the initial and annual costs are concerned.

But with such expensive fuel, the operating cost for gasoline and lubricating oil alone, based on the assumption previously stated, amounts to from $50.00 to $60.00 per million gallons pumped, depending on the capacity of the pumping units. The cost of pumping with gasoline engine driven auxiliaries is from three to five times as great as it is with any other kind of auxiliary equipment considered.

Obviously as the load factor of the auxiliary plant increases, the economy of the gasoline engine driven type fades in comparison with the oil engine driven type.

If it be conceded that there ought to be at least two units in an auxiliary plant, then for a small installation serving about 5000 people, the normal pumping load can be carried by the auxiliaries from five to six hours every day, before oil engines can compete with gasoline engines on an equal basis, so far as total annual costs are concerned.

In larger plants oil engines show to better advantage. A two to three hours daily run is enough to equalize the annual costs when the population served by the plant reaches 25,000. And it so happens that for twice this population half the length of run suffices to give the same result.

It was perhaps hardly worth while bothering with estimates of single unit plants at all. However the data were at hand and under certain conditions one might be inclined to take a chance on a single

unit plant, as for instance when the town is small, is expected to grow rapidly, and there happens to be elevated storage available.

Unless the water has to be pumped against a high pressure it will cost somewhat less to install and operate an oil engine driven auxiliary plant, if the engines are connected to pumps than to generators. But the latter plant is better adapted to a mixed service, where a variety of small powered equipment has to be taken care of.

Oil engine driven generators possess a most important advantage over oil engine driven pumps, in as much as the auxiliary plant can be more fully utilized to flatten the peak in the electrical power load for the whole town. All that the oil engine driven pumps can do is to reduce the peak by the pumping load. This on the average may be taken as equivalent to the normal domestic draft, which for towns with populations ranging from 5000 to 50,000 people, requires only from 25 to 50 per cent of the power installed in the auxiliary plant.

Where the pumping station pressure is boosted for large fires, the normal pumping load may represent still smaller percentages of the capacity of the auxiliary plants.

Peak loads are an important factor in the cost of the electrical power supplied a town, representing a much larger proportion of the power bill than of the energy used. Carrying part of this peak affords a good opportunity for the auxiliary plant, at least in part, to pay for itself.

The common expression "that every case must be considered on its merits," applies to a choice of engines for auxiliary plants. Where the auxiliary plant is to be used simply as a standby, that is to say only when the electrical power fails, it is usually a case for gasoline engine driven centrifugal pumps.

Of course, such a low-powered engine is not well adapted for large plants, but up to capacities of 10,000,000 g.p.d. at 100 pounds pressure, four units suffice and there can be no objection to that many. It must be remembered that usually two of them will carry the load when the power fails.

Gasoline engines cannot perhaps show the best of records as standbys so far as reliability is concerned. Overloading has been partly, if not largely, responsible. However this may be, it was the the only type of standby equipment that many municipalities were disposed to adopt during the last five or ten years. The prices of oil engines are now much more favorable than they used to be, but knowing what their motor-driven plant (which is to them their main

pumping plant) has cost them, the estimates for oil engine driven auxilaries will still often appear formidable to those who have to finance the work.

Where the motor driven pumping plant is supposed to get off the line during peak loads, and there is little or no elevated storage available, gasoline engines are still contenders in the smaller plants. It is not easy, however, to make out a case for them against oil engines, as auxiliaries serving communities with a population of 25,000 people or more.

Semi-Diesel engines do not cost as much as Diesels to install. They run at lower pressures, and have fewer working parts in the way of valves, levers, shafts and cams. They are not, however, so convenient to start, as heat must be applied to the cylinders with a blow torch for a minute or two, unless the engine is equipped with a so-called electric starting device.

At present prices, there is little to choose between Diesel and semi-Diesel engines so far as total annual costs are concerned. It is largely a matter of deciding in any particular case, whether the higher efficiency of the Diesel is worth the additional complications it involves. Obviously the smaller the plant, and the less it is to be used, the better the semi-Diesel engine compares with the Diesel.

DISCUSSION

Mr. Gore suggested that the responsibility for keeping the wheels turning at all times should rest with the Hydro-Electric Power Commission of Ontario and not with the municipalities. The Hydro, he thought, might well afford to install large Diesel-engine standby plants that would avoid any interruption in the current supply.

It is not possible, said Mr. Gore, for oil engines or gasoline engines to compete with the Hydro for normal operation in many towns in Ontario. He had recently considered Diesel drive for one small station, but had found that the establishment and operating charges exceeded by $100 a month the cost of Hydro power. Although gasoline engines are most suitable to installations of comparatively small horse-power, when very large installations are considered it would likely be desirable to install oil engines or steam, because the gasoline engines are not yet made in very large units—not much over 300 h.p., thought Mr. Gore—and it would be too difficult to try to start a number of units in an emergency.

Mr. Lea mentioned the case of one town where he had installed a gasoline engine standby, where the electric plant failed to operate for a month, and the gasoline engine carried the town for the month, running at high speed and heavily overloaded.

Mr. Norman Wilson asked how many gasoline engines would be required to pump 8 m.g.d.

Mr. Lea replied that, considering 8-cyl. engines of 180 b.h.p., direct connected to centrifugal pumps of 70 per cent efficiency, pumping 2½ m.g.d. against 100 pounds pressure or 230-feet total lift, three would be not quite enough and four would be too many.

Mr. Wilson: How many oil engines would be required?

Mr. Lea replied that oil engines are available in nearly any size ordinarily desired for this service. If the town were small and developing rapidly, it would seem desirable to install at least two, each capable of carrying the whole load. Whereas for larger and slower growing communities, three might be better, each 50 per cent of present requirements.

Mr. C. D. Brown enquired whether Mr. Lea knew of any cases where gasoline or oil engines in residential districts had caused complaint on account of an objectionable feature.

Mr. Lea replied that he knew of two cases where noise had caused complaint, and also one case where action had been taken against the muncipality on account of vibration. In this case the ground water was up to the level of the foundation and the vibrations were readily transmitted for 200 or 300 feet. There is no smell, said Mr. Lea, and noise can be taken care of by muffling, with a little sacrafice of power, and if properly installed there should be no vibration.

Mr. Dallyn enquired whether there is any automatic equipment available for the operation of remote stations whereby a standby plant can be cut in or out.

Mr. Lea replied that there are very acceptable methods for remote control of motor-driven pumps, but not of gasoline or oil driven engines. The engines must be started by hand, and when stopped the fuel supply might require attention, and in any event nobody would care to leave a 6, 8 or 10 m.g.d. plant running without an attendant.

Mr. Ray Knight enquired whether for small municipalities an ordinary motor truck would not suffice as a standby motor for a waterworks pumping plant. He suggested that the truck be backed into the plant, jacked up and a belt put over the wheel.

Mr. Lea replied that one of the main objects of standby units is to comply with the requirements of the fire underwriters, so that a better fire-insurance rate can be obtained for the municipality; and the underwriters will not permit a belted connection of any kind—not even a belted exciter for a generator—and moreover would undoubtedly object to the truck idea anyway, as the truck might not be there when wanted. In any event a 40-h.p. gasoline engine is not a great expense, and that is all the power that a truck would likely afford.

Mr. Darling said he had installed one station where, if fires had occurred during the town's peak load, and the pumps had been motor driven, each fire would have cost $300 for electric power, on account of boosting the peak. That would pay for 1000 gallons of gasoline.

Mr. Dallyn: How often should auxiliary units be tested? Is once a week satisfactory?

Mr. Lea: At least once a week.

Mr. Wilson: We turn our engines over every day.

Mr. A. U. Sanderson: In the Toronto plants every unit is tested once a week, and once a month it is placed under full load for a considerable period. This involves considerable work in switching, but in a large plant, it is very advisable. What developments have there been in the manufacture of units of large capacity, say 5000 h.p.

Mr. Lea: Oil engines have been made up to 6,000 h.p., and some manufacturers had developed up to 1000 h.p. per cylinder. It is only a question of using enough cylinders. I do not know the possible limits.

Mr. W. G. Chace raised a point in connection with the parallel operation of centrifugal pumps, one motor driven and one oil-engine driven, to keep down peak-load costs.

Mr. Lea: With the same pumps and the same conditions, just as good results could be obtained with oil engines as with motors, in parallel operation.

Mr. Chace said that with motors there is an electrical interlock as to speed. With an oil engine this speed regulation is not so easy and the motor might not get the expected relief unless the units had careful adjustment throughout operation.

Mr. Lea replied that the operator can readily see the speed at which his oil engine is running and that it is easy to regulate it without delay, and with proper governing system the speed should be maintained very accurately.

Mr. H. G. Hunter said that at the Cartierville filtration plant he connected the exhaust to the wash-water drain line and one cannot hear the unit running. At other plants he has connected the exhaust into a chimney, or installed a pit 3 or 4 feet square, 4 feet deep, covered with a grating and filled with stone and exhausted to the bottom of the pit. The pit must be drained, of course.

At Cartierville the operator fell asleep one night while filling his clear-water basin, and the overflow put three motors out of commission for sixteen days. The Sterling engines ran the 7½-h.p. low-lift pump and the 85-h.p. high-lift pump almost continuously during that period, the longest non-stop run being 56 hours.

Mr. R. Walters said that a rumbling noise is noticed in some of the Leamington residences at times. The vibration is not due to water hammer, he thought, but more likely to air in the lines. All their mains are laid in ground water. They have reservoirs, steam plunger pumps, no gear drive, no high suction lift, and have not been able to trace the trouble.

Mr. Harry F. Huy said that he had found rumbling in one case to be due to a vacuum pump in a heating system in a large school. Where plumbing is loosely installed anywhere in the town, vibration can be transmitted for a long distance.

Mr. Walters: Our trouble is sometimes in one part of the town and sometimes in another section.

Mr. Robt. Dyson suggested that there might be a deficiency in the air chambers of the pump.

Mr. Kellner said that the noise usually is not in the mains, but in the house plumbing. Several cases were investigated in Windsor and the plumbing was found to be quite loose. In one case the screw of the faucet spindle was very loose. When using centrifugal pumps, vibrations are transmitted along the line and are augmented by any loose plumbing which can vibrate in unison.

Mr. Gore stated that similar trouble had been experienced near the Sunnyside station in Toronto, where a number of houses had been disturbed for a long period. The trouble had been investigated by Mr. Milne, mechanical engineer of water works, who had come to the conclusion that it was due to certain dead ends.

There are always oscillations in water mains, and dead ends can readily cause trouble. In London investigation of disturbances due to reciprocating engines clearly showed waves and nodes of vibration, and it has been necessary in one case to build special rubber-mat foundations for the units.

Mr. Starr said that he has a 5-gallon tank inside the building, fed by hand pump.

Mr. Dyson said that last July they had installed two 8-cylinder gasoline engines and had been informed that they would be required to have at least thirty-six hours' supply of gasoline on hand. After considerable correspondence, the underwriters had consented to cut this down to twenty-four hours. The gasoline engines are used whenever a fire alarm comes in, as their bill would be boosted $75 to $90 for twenty minutes' operation of the pumps during a peak load, and in any event no water is used for 75 per cent of the alarms, so that the average run is very short, and it has been found desirable to use the standby units. So far there has been no complaint from the underwriters.

Mr. Hunter explained the requirements of the underwriters in Quebec. A storage tank must be 16 feet from the building, and underground. An auxiliary tank is fed by a hand pump. The piping must be of copper with soldered joints. No gasoline must be left in the unit after the run is finished, but must be drawn back into the storage tank.

A NEW DIFFERENTIAL TEST FOR MEMBERS OF THE COLON GROUP OF BACTERIA

STEWART A. KOSER[1]

It is now well established that the "B. coli" of the earlier workers in the field of sanitary bacteriology was in reality a broad group of organisms, the members of which are encountered in widely different habitats in nature and which differ from one another in many minor characteristics. The desirability of classifying this group became evident at an early date, for it was recognized in sanitary water work that certain members of the group might be more significant than others as indicators of pollution. The earlier attempts at classification were founded largely upon the qualitative fermentation of sugar media, chiefly sucrose, dulcitol, mannitol, raffinose, inulin, and salicin. On the basis of these fermentations, together with certain cultural tests, several elaborate classifications of the group were made. In general these classifications were highly artificial, numerous varieties of "B. coli" were created and there was no striking correlation between these varieties and the natural habitat of the organisms.

A most valuable contribution to the subject of water bacteriology was made about ten years ago by Rogers and his associates (1) who showed that on the basis of dextrose metabolism the colon group, or colon-aerogenes group as it is sometimes called, may be divided into two chief subgroups, the Bact. coli and the Bact. aerogenes sections. Subsequent work (2) has demonstrated that the differences in dextrose metabolism manifested by these two subgroups may be brought out in several ways: first, by determination of the ratio of gases (CO_2:H_2) evolved during anaerobic fermentation, second, by determination of the acidity in a special dextrose medium (the well-known methyl red test) and, third, by the Voges-Proskauer reaction. It has also been found (3) that the coli type may be separated from the aerogenes section of the group on the basis of the utilization of uric acid. The intestinal Bact. coli refuses to develop in a synthetic uric acid medium while the members of the Bact. aerogenes grow readily.

[1] From the Department of Bacteriology, University of Illinois, Urbana, Ill.

The natural habitat and the present methods of differentiation of the two chief sections of the colon group may be summarized as follows:

	SECTIONS OF THE GROUP	
	Bact. coli	Bact. aerogenes
Habitat	Constitutes about 95 per cent of the colon group organisms in the feces of man and warm blooded animals	Predominating type in soil and on grains. Occasionally found in intestine
Differential methods:		
Methyl red test	Positive (acid)	Negative (alkaline)
Voges-Proskauer reaction	Negative	Positive
Gas ratio $CO_2:H_2$	Low ratio, 1:1	High ratio, 1:5 or more to 1:0
Uric acid medium	Negative (no growth)	Positive (growth)

Atypical cultures as well as variations in these tests have been reported by most of those who have worked extensively with this group of organisms. However, these atypical forms constitute only a small per cent of the colon group cultures usually encountered so that as a general rule the above methods of differentiation serve nicely.

In spite of these differences between the two sections of the group, the desirability of their use in practical sanitary water analysis is still a disputed point. The determination of the gas ratio is a cumbersome procedure requiring special apparatus and is out of the question in the ordinary laboratory. Of the remaining tests, the methyl red and Voges-Proskauer tests are the best known and the most commonly used. In recent years they have been tried in water work but their practical value seems to be unsettled, some workers claim that they add nothing to the accepted methods of bacteriological water analysis, while others state that they are of definite value.

It is the purpose of this paper to call attention to a new differential test which is somewhat simpler than the former ones and which may prove to have some practical value. Briefly, it depends upon the inability of the intestinal Bact. coli to utilize citric acid, or sodium citrate, as a source of carbon, whereas the aerogenes section does

attack and utilize the citrate. In a simple synthetic medium containing a citrate as the only source of carbon the intestinal Bact. coli refuses to grow and the culture tubes remain clear. On the other hand, Bact. aerogenes and related types develop quite readily, the tubes become turbid after 24 to 48 hours and at the third or fourth day there is usually a heavy growth. This difference may be brought out very easily by either one of the following synthetic media:

I.	Distilled water	1000 cc.
	NaCl	5.0 grams
	$MgSO_4$	0.2 gram
	$(NH_4)\ H_2PO_4$	1.0 gram
	K_2HPO_4	1.0 gram
	sodium or potassium citrate	2.0 grams
	(sodium citrate · 5½ H_2O	2.77 grams
	or potassium citrate · H_2O	2.12 grams)
II.	Distilled water	1000 cc.
	$Na(NH_4)\ HPO_4 + 4\ H_2O$ (microcosmic salt)	1.5 grams
	KH_2PO_4	1.0 gram
	$MgSO_4$	0.2 gram
	(sodium or potassium citrate as given in I)	

If desired, 2 or 3 grams NaCl can be added to the second combination to make the medium more nearly isotonic. It is important that no carbon-containing compounds other than the citrate be present since they might permit the development of the coli type and thus obscure the differentiation. Both of the foregoing media are clear and colorless and require no adjustment of the reaction. The hydrogen-ion concentration is slightly on the acid side of neutrality, pH 6.6 to 6.8. They are filled into ordinary test tubes in 5 to 8 cc. amounts, sterilized in the autoclave at 15 pounds pressure for fifteen minutes and after cooling are ready for inoculation. These media have been used for the past two years by the writer in studies of the colon group (4) and have been found to constitute a very simple method of distinguishing fecal Bact. coli from other members of the group.

The citrate differentiation is perhaps somewhat easier to apply and appears to possess certain advantages over the methyl red and Voges-Proskauer tests. Either of the citrate media can be readily prepared by simply dissolving the salts in the required amount of water. The medium required for the methyl red and Voges-Proskauer tests is composed of Witte's peptone or a special proteose peptone and, fur-

thermore, variable results are sometimes secured by the use of different peptones. In the citrate medium crystalline salts are used entirely, thus doing away with any complex and perhaps variable substances such as proteoses and peptones. In addition, the results in the citrate medium can be determined at a glance, whereas to complete the methyl red and Voges-Proskauer tests it is necessary to add certain reagents—either methyl red indicator or potassium hydroxide—to the cultures and then record the results, in the case of the Voges-Proskauer test after allowing the tubes to stand for some time.

Another point of interest in regard to the citrate test is in the differentiation of certain soil organisms very closely resembling the fecal Bact. coli. In the examination of unpolluted woodland and forest soils by the writer (4), colon group organisms were frequently encountered and among them were a number of cultures which were methyl red positive and Voges-Proskauer negative. That is, on the basis of these two tests these organisms would be classed as fecal Bact. coli. However, when these cultures were tested in the citrate medium, practically all of them developed readily and in this respect they were distinct from the typical intestinal Bact. coli.

In the past it has been commonly assumed that all methyl red positive colon group cultures encountered in water, soil and other situations in nature outside of the body were of intestinal origin, even though remotely removed from any evident source of pollution. Upon applying the citrate test, however, most of these methyl red positive soil organisms could be distinguished from the fecal Bact. coli. The relationship of the citrate differentiation to the habitat of the organisms and to the methyl red and Voges-Proskauer tests may be shown as follows:

	INTESTINAL (BACT. COLI FROM MAN AND ANIMALS)	SOIL ORGANISMS	
		Intermediate (?)	Bact. aerogenes, etc.
Methyl red	+	+	−
Voges-Proskauer	−	−	+
Citrate medium	− (no growth)	+	+

The organisms recovered from soil which resemble the intestinal coli in respect to the methyl red and Voges-Proskauer tests are shown in what is tentatively designated as an "intermediate" section.

These were encountered less frequently than the Bact. aerogenes section, but were nevertheless found in appreciable numbers and seem to stand apart as a separate section. Their differentiation from the typical fecal Bact. coli on the basis of the citrate test is quite distinct, for they apparently grow as readily in the citrate medium as do the members of the aerogenes section.

While in the foregoing table the three different types are shown as sharply defined sections or subgroups of the colon group, as a matter of fact a few intermediate or irregular cultures are usually encountered. Practically all previous investigators who used large collections of colon group cultures found at least a few individuals which gave irregular or atypical results with the methyl red and Voges-Proskauer tests. The same holds true for the citrate test. In a collection of over 200 cultures isolated by the writer from feces, water, and soil, several irregular types were found. Two fecal coli cultures developed in the citrate medium; one culture, apparently Bact. aerogenes, failed to utilize citrate; also, one or two cultures were found which were difficult to place in any section on the basis of the differential tests. On the whole, irregular or atypical cultures were encountered infrequently and did not detract from the value of the test. As with all biological work a few intergrading or intermediate forms must be expected. In the series of colon group cultures collected by the writer the greatest amount of variation was found to be in the deportment of the soil cultures toward the methyl red and Voges-Proskauer tests.

The citrate test, in view of its simplicity and its promise of value in separating the fecal Bact. coli from other members of the group, seems deserving of further study by those interested in sanitary bacteriology. It should be pointed out that the citrate test, as with the other differential tests, should be applied only to pure cultures of colon group organisms. Thus, in following the standard methods of water analysis (5), lactose broth tubes which have been inoculated with the water sample in question and which show fermentation are streaked upon Endo plates or eosin-methylene blue plates. From colon-like colonies on these plates, agar slants and second lactose broth tubes are inoculated to finish the "completely confirmed" procedure. If the differential tests are applied, it is from these same colonies that tubes of citrate medium and medium for the methyl red and Voges-Proskauer tests should be inoculated. To obtain data of any value a series of colon cultures from each water sample,

wherever this is possible, should thus be isolated and run through the differential tests.

At the present time, the greatest need would seem to be the study of the occurrence of the several types of colon group organisms—as determined by the differential tests—in different classes of natural waters of known sanitary quality and the correlation of these data with the sanitary survey.

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THE MOST INTERESTING EXPERIENCE RECENTLY ENCOUNTERED IN WATER TREATMENT[1]

THE EFFECT OF LARGE RESERVOIR ON WATER SUPPLY QUALITY

MR. JAMES W. ARMSTRONG:[2] I wish to say a few words regarding the changed condition in operating Montebello Filters, caused by raising Loch Raven Dam a height of 52 feet. The day before I started for the water works convention one year ago, water flowed over the crest of our new dam for the first time, thus filling to the brim an impounding reservoir covering about 2500 acres of land and holding 23,000,000,000 gallons of water. The country surrounding the new reservoir is hilly and very irregular in shape; consequently, there are many inlets and little coves into which the water is backed. Many of the coves are quite shallow and are very favorable for the growth of all kinds of organisms. When it is understood that the shore line is about 50 miles long and that before flooding the ground was covered with vegetation, it can easily be seen what a tremendous opportunity for the growth of vegetable and animal life the new reservoir presents.

This will be especially appreciated when it is understood that the raising of the water surface has greatly increased the cross sectional area of the stream and has very much reduced the velocity of flow, so that the movement of the water in the broad expanses and in the coves is caused principally by the wind.

The covering of this large area of ground with water has to a large extent changed its character, and has in many ways changed operating conditions at Montebello. I have taken from our records a few figures which show what the changes in water conditions have meant in the way of plant operation. In using these figures, it should be borne in mind that they are monthly averages and do not represent any extremes. Therefore, they are better for general comparison. I have compared the years 1920 and 1921 with the

[1] Presented before the Chemical and Bacteriological Division, New York Convention, May 21, 1924.

[2] Filtration Engineer, Water Department, Montebello Filters, Baltimore, Md.

year 1923, omitting the year 1922, for during 1922 the reservoir was in the course of filling and represented a transition period. In order to show at a glance what the flooding of the new area has meant in plant operation, I am showing the results in two columns, one of which lists the increased difficulties encountered and the other shows the gains.

Gains	*Losses*
Cooler water	More organisms
Reduced turbidity	Poorer floc
Fewer bacteria	Shorter filter runs
Fewer colon bacteria	Clogging of sand
Less chlorine required	Trouble with manganese
Less alum required	
Freedom from sudden changes	

Cooler water. In comparing the temperature of the water, averages were taken for the months of June, July, August and September. During the winter months there was very little change. By comparing the figures, it will be noted that there was a net average gain for the four months of 6° F. in the coolness of the water.

	1920	1921	1923
	°*F.*	°*F.*	°*F.*
Average air temperature	74.35	75.9	74.65
Average water temperature	72.00	73.5	66.22
Net gain in coolness	2.35	2.4	8.4

Turbidity. The mere comparison of turbidities does not tell the whole story due to the changed conditions. While the reduced turbidity did result in a large saving of alum, the gain was not proportional to the reduction, as it took more alum to form a good floc, and the floc was looser and more easily broken up than formerly. The looseness of the floc was clearly revealed under the microscope, and by means of laboratory tests it was proven that the floc was readily broken upon striking the filter sand. The average reduction in turbidity from about 85 to 8.5 has resulted for the year 1923 in saving 4300 pounds of alum per day, which at a price of $23.00 per ton makes a total saving for the year of $18,000.00.

From an operating point of view, the reduction in turbidity and the freedom from sudden changes has proven a great blessing to the laboratory force and the men who mix and handle chemicals, as it

has relieved them of practically all anxiety formerly caused by the uncertainty as to what was going to happen next. There are now no calls in the middle of the night when a sudden storm occurs.

	1920	1921	1923
Average turbidity	91	79	8.4
Maximum turbidity	231	459	11.0
Average alum, grains per gallon	1.29	1.04	0.87
Maximum alum, grains per gallon	2.14	2.51	1.42

Fewer bacteria. The reduction in bacteria was very marked in both the 20° and 37° counts and also in B. coli. The higher forms of organisms which were so prevalent in the water destroyed many, and the sunshine and wind also played a part.

	1920	1921	1923
Bacteria per cubic centimeter 20°C. raw water			
Average	16,189	5,438	218
Maximum	85,687	38,043	528
B. coli per cubic centimeter raw water			
Average	41.13	58.60	0.93
Maximum	130.04	183.47	2.27

Organisms. As the flooded area covered nearly 2500 acres, and the stream flow was such that it took months to fill the reservoir, it presented an unusual opportunity for the growth of organisms. The multiplication of these organisms troubled us in two ways: first, in our settling basins, and second, with the filter sand. It was also thought that the presence of so many organisms interfered to some extent with the proper action of alum as a coagulant, as the increased amount of alum necessary to secure a proper floc could not be accounted for by comparing the required amount with the turbidity curves established by past experience.

After the water began to rise in the new reservoir, great numbers of Bryozoa were noticed in the water. These organisms coming in fairly large masses were generally precipitated in the coagulating basins where they settled to the bottom and went through a process of decomposition. The resultant gas formed, caused particles of

sludge to rise to the top of the basins, resembling very much the sludge that rises to the top of sewage septic tanks. It was not only unsightly but cast off an offensive odor, which necessitated our cleaning the basins several times when there was only a slight deposit on the bottom.

Other types of organisms, principally a slime-producing bacterium not yet identified, passed on to the filters and began to coat our sand grains. These growths did not seem to injure the quality of the water, but were first made apparent by matting and ridging the sand. The sticking together of the sand particles reduced the area available for filtration and shortened the filter runs to such an extent, that it was hard to secure enough water for supplying the city.

In order to clean the sand it was washed through an ejector and a Nichols sand washing machine. This relieved our troubles for a time, but during the hot season of the year the sand grains became recoated rapidly. With the advent of cold weather this trouble ceased to a very large extent.

	1920	1921	1923
Organisms in raw water			
Average number per cubic centimeter	163	259	4724
Maximum, number per cubic centimeter	457	954	12590
Length of filter runs			
Average time, hours	36.9	62.7	25.5
Maximum time, hours	60.2	100.1	37.1

An inspection of the list of organisms occurring in the greatest numbers reveals the fact that most of them belong to the animal kingdom. The presence of such large numbers of the higher type of microscopic organisms in the water means that there must also be an abundance of the lower forms to serve as a food supply. The problem of ridding the reservoir of organisms seems to be the one of preventing the growth of such forms as "algae," which thrive particularly in the warm shallow water.

In order to get rid of such places, we plan to purchase a small suction dredge boat with which we can deepen the shallow places, and fill in the low marshy places along the shore. It is believed that by deepening the shallow places, much good will be done toward purifying the water at the source.

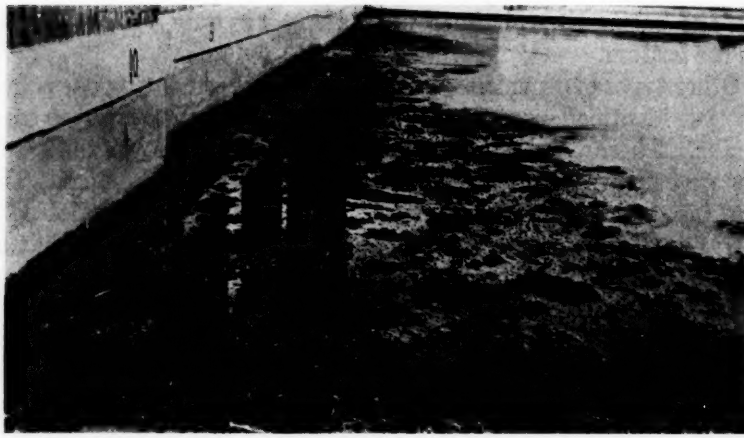


Fig. 1. Sludge on the Surface of the Coagulating Basin, Montebello Filters, Caused by Decomposing Organisms

Fig. 2. Matting and Ridging of Filter Sand Caused by Organic Growths on the Sand Grains

Organisms showing great increase after raising water level in Loch Raven reservoir

Diatoms:	Nemotodes
Melosira distans	Rotatoria:
Fragilaria	Polyarthra
Asterionella	Anuraea
Algae:	Pedalion
Staurostrum	Cladocera:
Protozoa:	Daphnia
Difflugia	Bosmina
Uroglena	Copepoda:
Dinobryon	Cyclops
Peridinium	Bryozoa:
Vorticella	Paludicella
Epistylis	Pulmatella polymorpha
Hydra:	Corethra (larva)
Porifera:	
Tubella pennsylvania	

Manganese. There is always something happening around a filter plant. Just as things seemed to settle down to smooth running, complaints began to come in from housekeepers that bath tubs were being discolored, and from laundries and hospitals that their linen was being stained. Investigation proved that the trouble was due to the presence of manganese in the water which had been absorbed from the rocks and soil of the freshly covered area. Mr. Baylis, who is to follow me, will tell more particularly what this trouble meant.

MANGANESE IN BALTIMORE WATER SUPPLY

Mr. John R. Baylis:[3] A sudden and unexpected increase of manganese in the Baltimore water supply in 1923, caused many complaints of it staining clothes and white enameled water fixtures. Most of the complaints were received during the months of October and November, being somewhat delayed from the time the increase started. The delay of complaints was due to the fact that it required some time for the stains to become noticeable, and that most of the laundries and other industries affected were looking for the trouble in their own plants. The increase was detected the first of August in searching for the cause of an interference with the ortho-tolidin test for residual chlorine. Black looking suspended particles helped

[3] Principal Sanitary Chemist, Water Department, Montebello Filters, Baltimore, Md.

to confirm our suspicion that something unusual was wrong. From occasional tests we were aware that the water contained small quantities of manganese, usually less than 0.1 p.p.m., but daily determinations were not being made at the time the increase started.

When the increase was detected no immediate attempt was made to remove it. In fact, we did not know the amount necessary to cause trouble, nor the extent of such troubles. The first complaint was from a dyeing plant the latter part of September, nearly 2 months after the increase started. Their chemist visited the filter plant to see if we could give any clue as to what might be staining his fabrics. About 2 weeks later the manager of a small laundry reported that clothes were being stained a brownish color in spots. A visit to the plant confirmed the fact that he was having serious trouble. The Water Engineer then immediately notified all laundries of the presence of manganese in the water. This gave them an excuse to offer many indignant customers and to apply, as far as possible, local remedies.

Cause of the sudden increase of manganese. To explain such a sudden increase in water from a source that has been used for a number of years without another objectionable occurrence has necessitated a careful study of all conditions that have been changed by the improvements on the Gunpowder River within the past few years. There is fairly conclusive evidence that manganese has not occurred previously in quantities greater than 0.2 p.p.m., except possibly in the fall of 1922. The water level in the Loch Raven reservoir on the Gunpowder River was raised about 10 feet above its previous level in the spring of 1922, and about 40 feet in the early part of 1923. There was considerable trouble from the filter beds clogging in 1922, and the dark incrustation around the sand grains seemed to increase slightly, but only one complaint of the water staining clothes was received. The manganese might have gone a little higher than usual in August and September, 1922, but it did not go nearly so high as it did in 1923.

All the main streams entering the Loch Raven reservoir were free from manganese in quantities over 0.1 p.p.m. when tested on 2 different occasions at the time the increase was highest. The reservoir was free from manganese in the part of it just above an old mill dam which is now submerged a few inches. This dam is near the upper part of the reservoir and is across the river that supplies about three-fourths of the water. Since the streams entering the

reservoir are practically free from manganese it makes the proof almost conclusive that the manganese is coming from the rock underneath. Years ago there was an iron furnace operated at Ashland, a small village on the Gunpowder River and now near the upper part of the reservoir, but below the old mill dam. The ores were obtained in that vicinity, and we are reliably informed that the iron contained considerable manganese. All rock examined from the vicinity of the reservoir has been found to contain small quantities of managanese. The chemical combination in which it occurs is not known, but it is most likely an oxide or carbonate. Either is slightly soluble in the presence of certain organic acids. From the fact that manganese resembles iron somewhat it is likely the acids which will dissolve one will dissolve the other.

We are aware of the fact that the oxides of iron are dissolved under certain conditions. Harder (1) states that the iron compounds are dissolved by the action of acids present in ground and surface water. The principal acid in ground water is usually carbonic, but variable amounts of other acids such as butyric, propionic, formic, citric, lactic, acetic, tartaric, valerianic, humic, crenic, aprocrenic and ulnic may be present. They are largely the results of decay of organic matter by biological action. Marshall (2) states that organic acids are formed by nearly every important species of soil bacteria, and that the tissues of dead plants and animals are not the sole source of organic acids in soils. He also states that they are not likely to accumulate in well ventilated soils as molds and other bacteria destroy the acids rapidly. This offers excellent proof of why the organic acids become more concentrated when the air is excluded, and may offer a clue as to why certain organisms precipitate iron and manganese. They may break down the complex and soluble organic acid compounds of iron and manganese. Löhnis and Fred (3) give carbon dioxide and humus as the main products formed by bacterial action on decaying vegetation, but they state that organic acids, alcohols, methane and hydrogen may appear as by-products. Moody (5) says that carbonic acid exerts a great corrosive influence on iron, which may be even greater than hydrochloric or sulfuric. The oxides of iron are not attacked very readily by carbonic acid, and while the most of the soluble iron in water is supposed to be a bicarbonate of iron the proof we have is none too positive. We are aware that some of the other organic acids are more effective in dissolving the oxides of iron and manganese. Kendler (5) as early as 1836 called attention to the fact that decaying vegetable matter has a marked effect on the solubility of ferric hydroxide. He noticed that ferruginous quartzose sand was rendered colorless around decaying roots and in a few months became as white as if it had been treated with an acid. A root ⅛ inch in diameter, upon decaying, whitened the sand to a distance of 1 to 2 inches around it. The writer has not been very successful in dissolving sterile oxides of iron and manganese with carbonic acid, but when a little beef extract and peptone was added to the solution and inoculated with water from in contact with sand from one of the filters, a biological

action took place which dissolved considerable iron and manganese. It has been found that particles of decaying organic matter, such as small fish, will cause sand heavily coated with iron and manganese to become almost white for an inch or more around the particle when found in clogged places in the filter beds.

When the surface soil in the Loch Raven reservoir was covered with water, conditions became favorable for certain biological actions to take place, which formed organic acids. The surface soil with the decaying vegetation produced a zone requiring considerable dissolved oxygen to take care of the biological actions. The diffusion of oxygen was not rapid enough for it to pass this zone, resulting in the water in contact with the earth and rock underneath having no dissolved oxygen. The demand for oxygen may have been so great in order to complete the process of decay that the oxides were reduced. If the oxides are reduced they are very likely more soluble with carbonic acid, which is always present under such conditions. Hawley (6) states that the oxides of manganese are readily dissolved by citric acid. This has been confirmed in our laboratory by using lemon juice. Tartaric acid also dissolved manganese from the sand grains very readily.

The diffusion of soluble manganese to the surface has probably been taking place since the water level was raised. Part of it was deposited near the surface of the top soil when it came in contact with dissolved oxygen. The precipitation at this point was probably aided by certain biological growths. As it passed through the tunnel, about 8 miles long from the reservoir to Montebello Filters, more of it was deposited on the sides of the tunnel by a luxuriant growth of schizomycetes. About the first of August, 1923, slime-producing bacteria started to grow on all surfaces in the reservoir, tunnels, basins, etc. The growth on the sand grains was delayed slightly on account of chlorine being used before filtration from July 28 until August 14. A previous occurrence of these bacteria in August and September, 1922 caused us to be on the lookout for them. Figure 1 shows camera lucida drawing of a sand grain made September 27. These bacteria require oxygen, and there was considerable reduction of the dissolved oxygen when they were present. For the month of October, 1923, the dissolved oxygen was only 35 per cent saturation, which is considerably lower than the average for the past 4 years. The oxygen demand of these bacteria is so great that filters, operated at the rate of 25 million gallons per acre per day, or

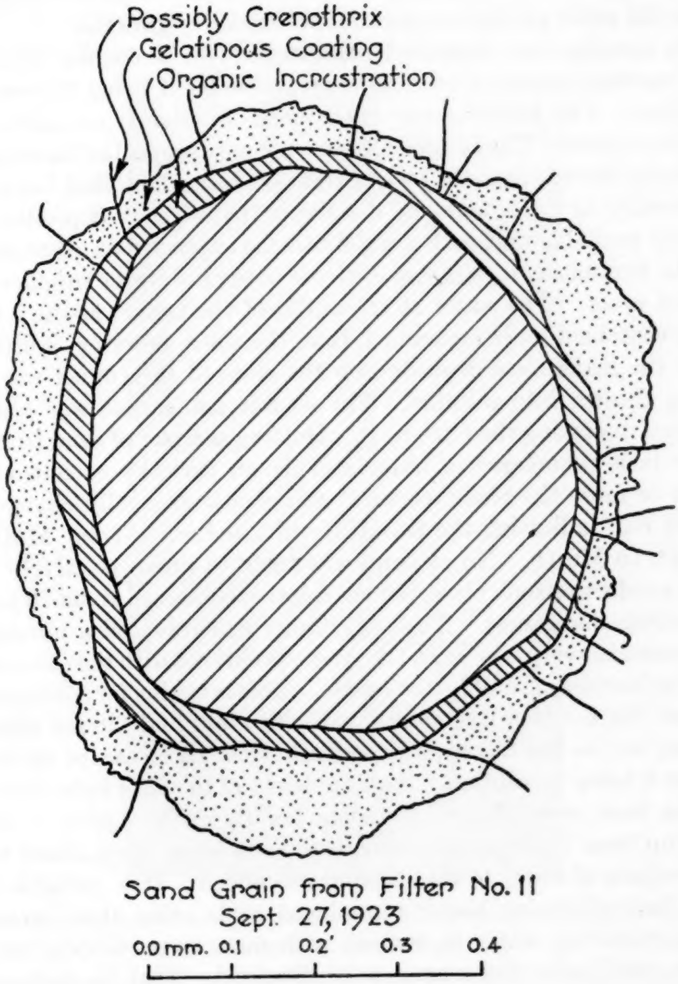


Fig. 1

There is evidence that the gelatinous coating started to grow on the sand grains during the latter part of August. Drawing of a grain dated August 23 shows no coating. This was ten days after stopping the application of chlorine to the raw water. The gelatinous g owth has killed out most of the filamentous growths which were so numerous during the summer. This coating has not only covered the sand grains, but all surfaces in contact with the water.

about one-fifth normal rating, removed practically all dissolved oxygen from the water passing during times of excessive growths.

In covering the deposited manganese with a coating of slime, the bacteria produced conditions favorable for it being thrown into solution. The bacteria may grow more abundantly on oxides that can be reduced. The biological action not only prevented the manganese being derived from the rock underneath being deposited, but added materially to the amount by dissolving that already deposited. It is very probable that such a condition has happened at other places, as the fluctuating manganese contents of several water supplies give added proof. The water at the outlet of the tunnel about 7 miles long contained more manganese than the water entering, indicating that the manganese deposited on the sides of the tunnel was also being thrown into solution. The soluble manganese was also increased in passing the filter beds. Holding samples of sand from the filter beds submerged in water and the air partially excluded for a week or more the black oxides of manganese gradually changed to a dull red, indicating the possibility of a reduction from MnO_2 or Mn_2O_3 to Mn_3O_4. No attempt was made to prove positively that such a reduction took place, but the solution contained about 10 p.p.m. of soluble manganese. This experiment was repeated a number of times and in every case when the sand was covered with the slime there was an increase of soluble manganese. Before testing for soluble manganese the solution was coagulated with alum and filtered through paper, and as the filtrate was perfectly clear there can be no doubt about it being in solution. Sand from any of the filter beds when the grains were covered with the slime as shown in figure 1 would give up from 1 to 2 p.p.m. manganese in 48 hours when about twice the volume of water to that of sand was added. It is probable that the slime-producing bacteria produced acids other than carbonic, for carbonating water in contact with manganese dioxide did not cause much more than a trace to be dissolved. That the manganese is thrown into solution is proven beyond a doubt, but the cause for precipitation is not so easily proven. Oxygen plays an important part, yet it will not cause the precipitation of any of the soluble or slightly soluble compounds of manganese. It is an essential, but it seems that something other than oxygen produces the hydroxide of manganese.

The photograph in figure 2 was made to show the shrinkage of badly coated sand from one of the filter beds by increasing the loss of head

when filtering. A few inches above the sand surface is noted an incrustation of manganese. About the first of September, 1922, the tube was filled with sand to a point opposite 5.1 feet on the level rod, which

FIG. 2. MANGANESE INCRUSTATION ON GLASS TUBE CONTAINING SAND—EXPERIMENTAL FILTER

About the first of September, 1922, sand from one of the filter beds was placed into the glass tube, thoroughly washed and allowed to stand five days. The surface of the sand after washing was opposite 5.1 feet on the level rod, or at the bottom of the manganese incrustation. Within two or three days a dark-brown incrustation started to form just above the sand surface.

is the bottom of the incrusted place, and after thoroughly washing it was allowed to stand undisturbed for about five days. A dark brown incrustation formed on the inside of the glass tube. It was thickest at the sand surface and gradually got lighter until there was practically

none 6 inches above. In attempting to wash the sand it was found that the top 3 inches adhered into a solid mass. The coating of manganese was probably deposited above the sand surface by the same process it was deposited in the Loch Raven reservoir. The biological action taking place beneath the sand surface consumed all the dissolved oxygen and probably liberated acids that dissolved some of the manganese. The soluble manganese, probably in chemical combination with a complex organic acid, diffused to the water above the sand containing dissolved oxygen. There may have been an oxidation, or breaking down, of the organic acid which released the manganese in an insoluble form, or certain manganese precipitating bacteria aided in the action. A number of experiments thoroughly confirms the fact that manganese may be readily precipitated in this manner. The fact that there was evidence of biological growths in the precipitated film on the side of the glass and the sand surface indicates that there might have been another biological action causing the precipitation. There are indications that the production of acids that will dissolve manganese is limited to a few species of bacteria, for it is only at certain times of the year that such a phenomenon will take place. In fact it is believed that one specie of bacteria has been responsible in the experiments conducted.

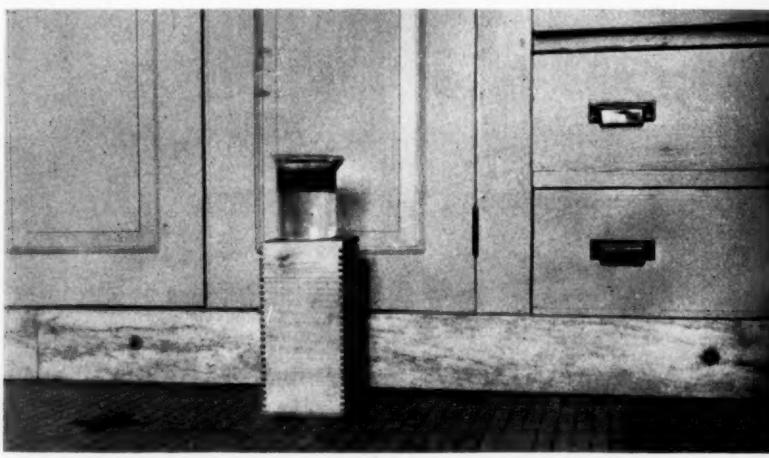
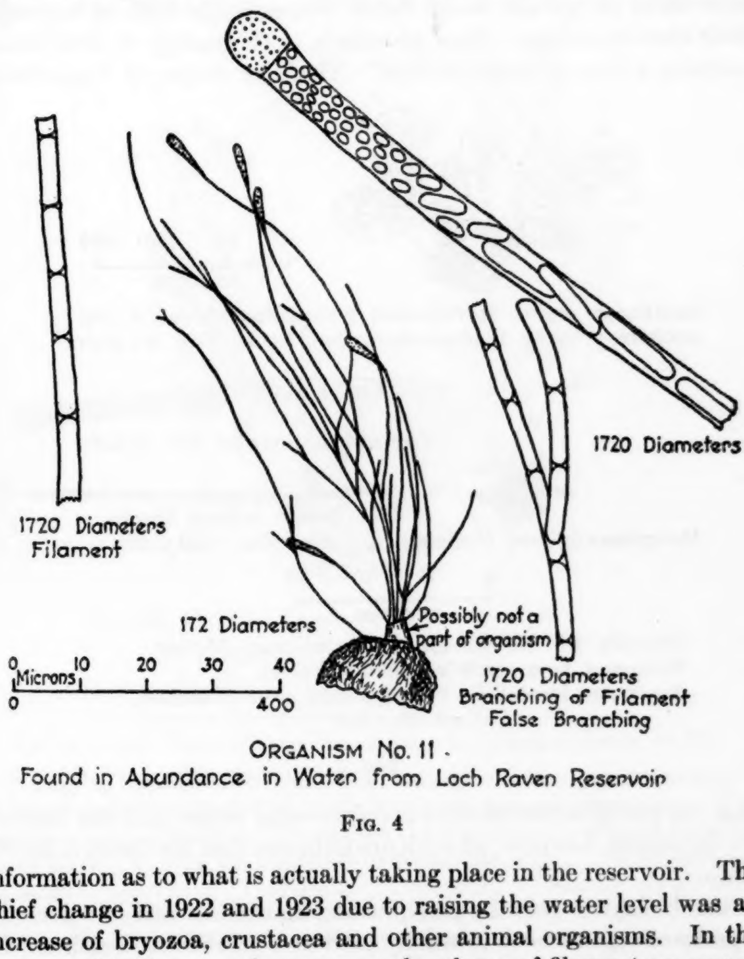


Fig. 3. Manganese Incrustation Caused from a Biological Action

Sand from one of the filter beds was allowed to stand in the beaker for two weeks. The biological action taking place dissolved the manganese coating from around the sand grains, and it was deposited on the top of the sand and the sides of the glass above the sand.

Biological Growths. Biology has evidently played such an important part in causing this trouble that it may be well to give some of the principal changes that have taken place since the water level was raised in the Loch Raven reservoir. A fairly complete record of the microörganisms in the water coming from the Loch Raven reservoir has been kept for several years. This, however, gives very little



ORGANISM No. 11.
Found in Abundance in Water from Loch Raven Reservoir

FIG. 4

information as to what is actually taking place in the reservoir. The chief change in 1922 and 1923 due to raising the water level was an increase of bryozoa, crustacea and other animal organisms. In the summer of both years, there was an abundance of filamentous organisms, mostly species of schizomycetes and molds, followed by a luxuriant growth of slime producing bacteria. Figures 4 and 5 show species of filamentous organisms occurring in great abundance both years.

The one shown in figure 5 precipitates iron and manganese. The slime producing bacteria started to grow in August of both years, and were very abundant in 1923. They covered all surfaces in the Loch Raven reservoir, tunnel, settling basins and filters. Figure 6 shows how badly coated were some of the sand grains in the filter beds. Figure 7 is drawing on a larger scale showing the bacteria. Attempts to grow them on culture media failed, consequently little is known of their characteristics. They produce a thick coating of slime which contains a large amount of silica. There, of course, is a possibility

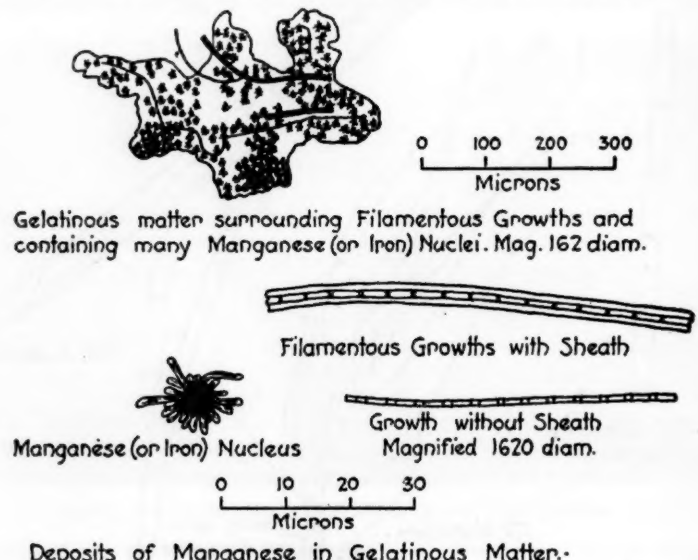


Fig. 5

that the precipitation of silica is due to other causes and the bacteria are incidental, however, all evidence indicates that the bacteria are the cause.

The biological growths precipitating manganese and iron includes a group of organisms that usually produce a gelatinous sheath or jelly masses, and probably of types that tend to break down organic acids. Any organism that will change or produce compounds that will change the composition of soluble compounds of manganese and iron may directly or indirectly cause precipitation. Harder (1) shows very

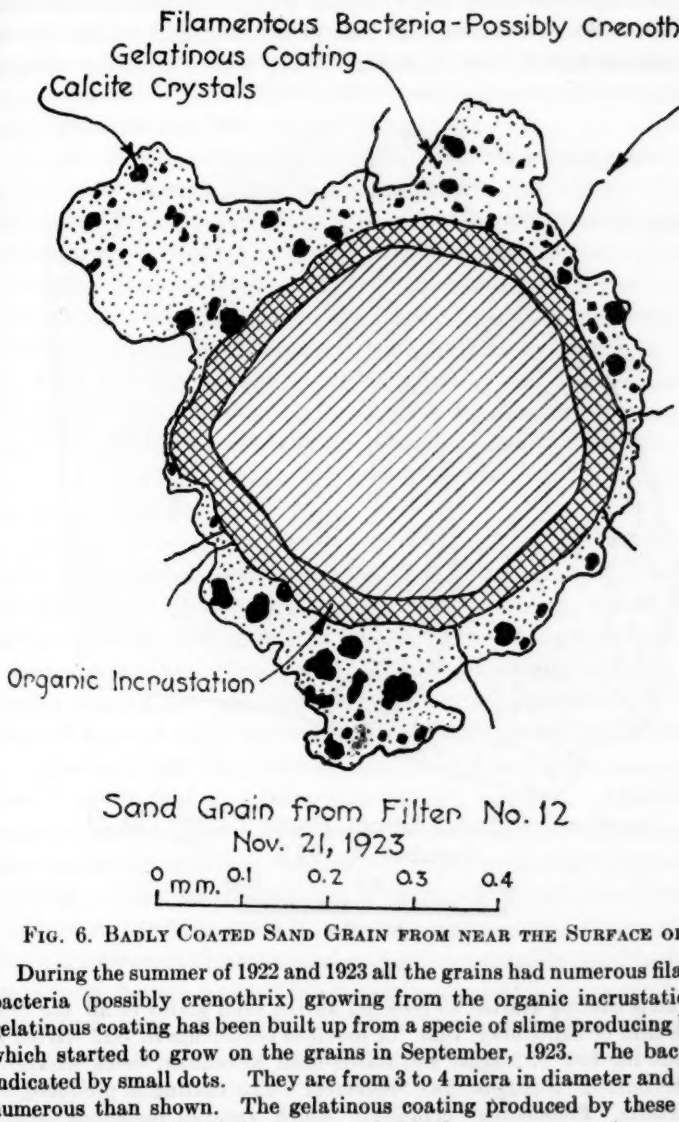
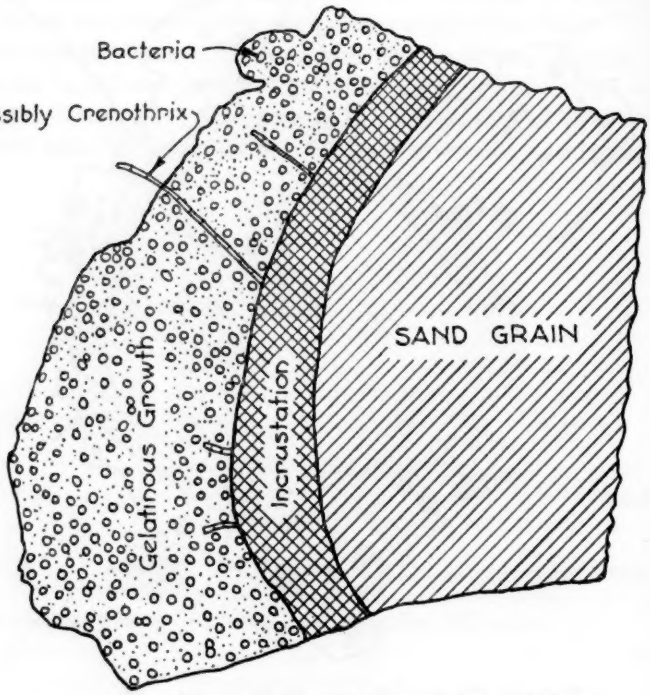


FIG. 6. BADLY COATED SAND GRAIN FROM NEAR THE SURFACE OF BED

During the summer of 1922 and 1923 all the grains had numerous filamentous bacteria (possibly crenothrix) growing from the organic incrustation. The gelatinous coating has been built up from a specie of slime producing bacteria, which started to grow on the grains in September, 1923. The bacteria are indicated by small dots. They are from 3 to 4 micra in diameter and are more numerous than shown. The gelatinous coating produced by these bacteria has overgrown and killed out most of the filamentous organisms, and have caused the filter beds to clog very badly. The use of iron and lime as a coagulant was started November 15, 1923. Numerous calcite crystals are observed in the gelatinous coating, which seems to form crystals more readily than the organic incrustation.

clearly there are species of bacteria that will precipitate certain iron compounds. He also shows that iron is not essential to the life of some of the so called "iron bacteria." The writer seriously doubts



Portion of Sand Grain from Filter No. 31
October 4, 1923
0 50 100
Micra

FIG. 7

Gelatinous coating started to grow on all the sand grains in all the beds about the first of September, 1923. A previous occurrence in 1922 started to grow about the first of August and lasted until November, being excessive during the months of August and September. The coating is produced by slime bacteria. Filamentous organisms, which were so numerous before growth started, have been reduced greatly.

the presence of iron or manganese being essential to the life of any organism. The fact that certain species of schizomycetes are usually associated with waters containing considerable iron is believed to be

due to the fact that they can live in the presence of these compounds, whereas other organisms can not. The presence of iron or manganese in water is very good evidence that it has contained considerable organic matter. It is believed the organic compounds serve as food for the organisms and not iron and manganese.

Extent of the manganese trouble. Manganese troubles may be divided into two general groups, staining and incrusting. The industries most affected were laundries. No one will tolerate manganese stains on white clothes. It is up to the laundries to prevent or remove the stains however costly. In our case the laundries were not aware of the presence of manganese until some time after they were having serious trouble. Each laundry thought the cause might be local, as there had never been previous trouble, and were cleaning and renewing water pipes in their plants. No one dared complain for fear it would reflect upon their business and cause loss of trade. Indignant customers were returning stained clothes, and in some instances changing laundries.

The fact that certain fabrics went through the laundrying process with practically no stains enabled us to form some conclusion as to the main essentials for staining. Greasy spots on towels, napkins, table covers, etc., stained first. Such fabrics are usually run through a bleach at the end of the washing process. White uniforms worn by nurses stained first around the neck and sleeves where the uniform came in contact with the body. Underclothes worn in direct contact with the body and not bleached, did not stain to a great extent. However, it seems that no fabrics were entirely immune. After the cause became known most laundries not using zeolite softeners, which ones we understand had very little trouble, were able to overcome the staining. They avoided the use of extremely caustic compounds, and many completed the wash in a slightly acid solution before bleaching. From the amount of oxalic acid sold it was probably used to the greatest extent, though some of the laundries used very successfully an acid compound used to set dyes. There was some staining of clothes washed at home, but the trouble was not so great as might have been expected. This was probably due to not using caustics and bleach to a very great extent.

The staining of white enameled water fixtures was greatest in the kitchen where grease came in contact with them, such as kitchen sinks. A few reported other articles stained, but it was not excessive.

Incrustation troubles, while not great at first, may become so later on. The report of almost complete stoppage of pipes at Pierre, S. D. (7), shows that it may become of great concern to the department in the near future unless the trouble is eliminated. It has increased our filter troubles by incrusting the sand grains and causing the filter beds to clog more readily. A reduction of manganese in the water after passing through the distribution system shows that the incrustation on the inside of the pipes is being built up. In reviewing briefly the reports of incrusting water pipes by manganese bearing waters, Corson (8) refers to articles by Weston (9), Raumer (10), Bailey (11), Jackson (12), Beythien (13), Vollmar (14) and Corson (15), which give a very complete record of troubles throughout the world. It seems evident from such reports that in practically every water supply where the manganese is present in quantities of 0.1 p.p.m. or over there is trouble from pipe incrustation.

Methods of removal. The large number of complaints from manganese staining, after it was known that this was the cause of the trouble, forced us to take active steps towards finding a method of removal. A review of available literature on manganese removal offered no great encouragement for immediate relief, for practically all previous attempts on a large scale has been by adsorption in filtering or percolating beds, frequently preceded by aeration. The fact that the adsorption process had been reversed by a biological action, not only in the reservoir and tunnel, but in the filter beds also, made it desirable to experiment along other lines for immediate relief.

Removal by precipitation with ferrous sulfate. Giessler (16) reports that by mixing the so called "Eichwald Water," containing 18 p.p.m. of Fe_2O_3 and 1.7 p.p.m. Mn_2O_3, with Herzog water containing 0.9 p.p.m. Fe_2O_3 and no manganese, in equal parts, removes iron to a trace and all manganese. Corson (8) found when equal parts of manganese as manganese sulfate and iron as ferrous ammonium sulfate were mixed and thoroughly aerated that all iron and practically no manganese was removed when filtered through clean sand. Dr. Arthur L. Browne, Penniman and Browne, Chemists, Baltimore, Md., suggested that ferrous sulfate might aid in the removal as the two elements had characteristics somewhat alike. The experience at the Posen Water Works as reported by Giessler also indicated that iron exerted some influence on the removal of manganese by precipitation. Consequently experiments were started with very encouraging results.

It is doubtful if any element occurring in quantities as low as 1 part per million or less can be successfully coagulated and precipitated without aid from some other precipitant. The conditions most suitable for precipitation may be the conditions under which it is precipitated easiest with another coagulant. Manganese is somewhat like iron in that the soluble compounds are usually converted into the insoluble hydroxide when the pH and alkalinity give points above the calcium carbonate equilibrium curve shown in figure 8. The manganese is much slower in action than iron and if quick results are desired the pH should give points considerably above the curve.

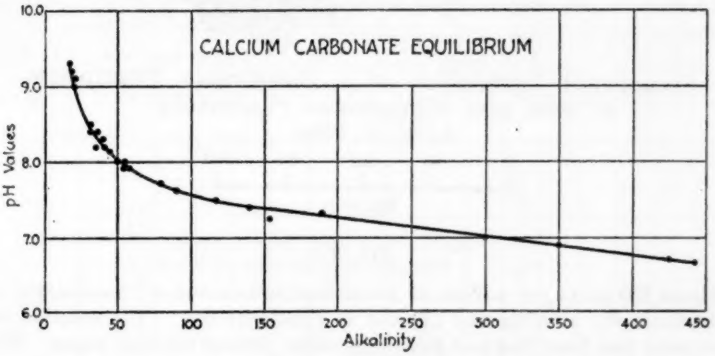


FIG. 8

About 50 grams each of calcium carbonate from three different sources was pulverized in a mortar and placed into 300 cc. glass stoppered bottles. Distilled and Baltimore City tap waters were used. High alkalinity concentrations were obtained by passing carbon dioxide gas through the solution. The bottles were filled full of water, the glass stoppers inserted, and then allowed to stand in the laboratory for one week. C. P. calcium carbonate, pulverized limestone and surface crystals from a saturated solution of limewater were used. The water was changed several times before the first results were recorded. All 3 samples gave results alike.

The structural formations of ferric hydroxide and manganic hydroxide, as shown by figure 9, appear to be similar when observed with the high power microscope. It may be that the spherules of manganese and iron arrange themselves into "chains of beads," or fibers, composed of both the elements rather than each element tending to form separate chains or fibers. In fact the molecules of both may adhere in forming the spherules, which seems to be indicated by figure 10. Whatever the process of precipitation may be, practically all manganese was removed with the coagulant when the water was treated

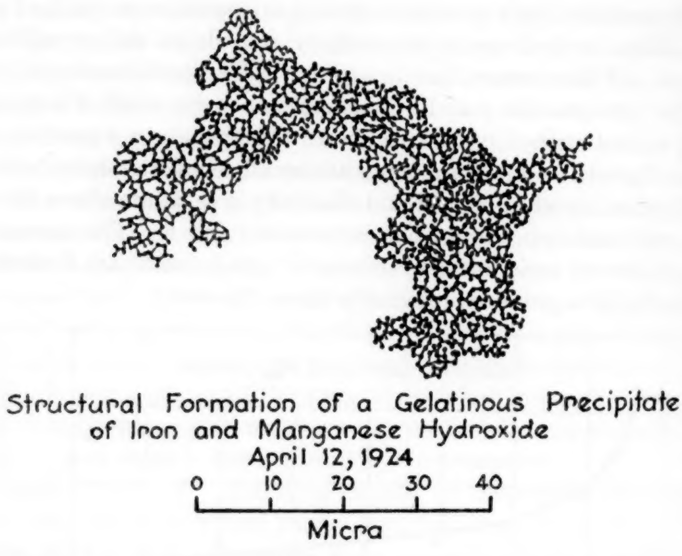


FIG. 9

About 100 parts per million of manganese sulfate and ferrous sulfate was made distinctly alkaline and allowed to stand one day. The solution was practically free from iron and manganese when filtered through paper. Most of the particles of floc were much larger and more compact than the above. This was selected to give a better idea of the structural formation.

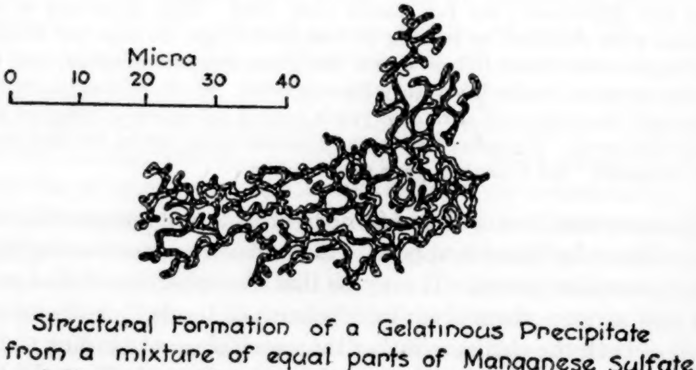


FIG. 10

with ferrous sulfate (shown in figure 11). There may be a certain ratio of precipitation between the two, which ratio is probably affected by the pH, alkalinity and other conditions. In the experiments conducted and in actual plant operation the iron was in considerable excess of the manganese. Ferrous sulfate was used as a coagulant in the plant from November 15 to October 2, 1923, and gave practically complete precipitation of the manganese. Filtering the coagulated water through paper gave complete removal, whereas with the alum coagulated water there was no reduction, showing that it was being removed with the iron. The mixing basin of the Montebello Filters is not designed for properly coagulating iron, and for this reason the cost of treatment was more than when alum is used. The fact that properly coagulated water with the use of iron and lime may be easily

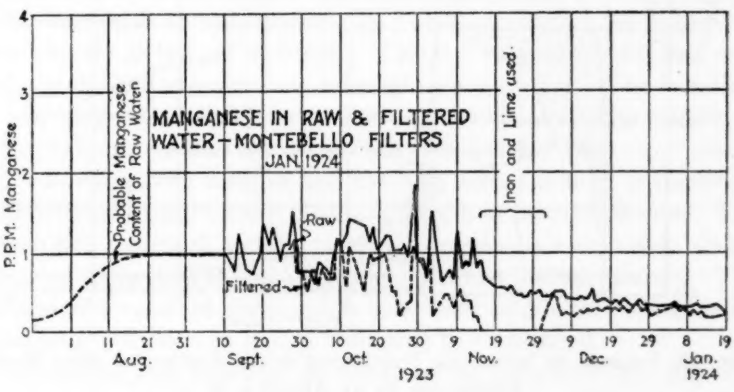


FIG. 11

obtained in the laboratory with much smaller amounts than are necessary for plant conditions shows that the trouble is in the mixing basin and not the coagulant. The structural formation of ferric hydroxide indicates that more is dependent on the proper physical forces to form a coagulation than is the case with some other coagulants, such as alum. When this is thoroughly understood it may be that iron can be successfully used for practically any character of water. Since the manganese is precipitated with the coagulant, it accomplished exactly what it desired. This will probably make it the most satisfactory method of removal where it is desirable to reduce it to a minimum. Laboratory experiments indicate that manganese sulfate is somewhat harder to remove than some of the other manganese compounds, but iron will still likely be the most efficient.

Removal by adsorption. Adsorption in filtering and percolating beds is usually a very cheap and in many instances a fairly efficient method. Removal by this method has been fairly well covered in

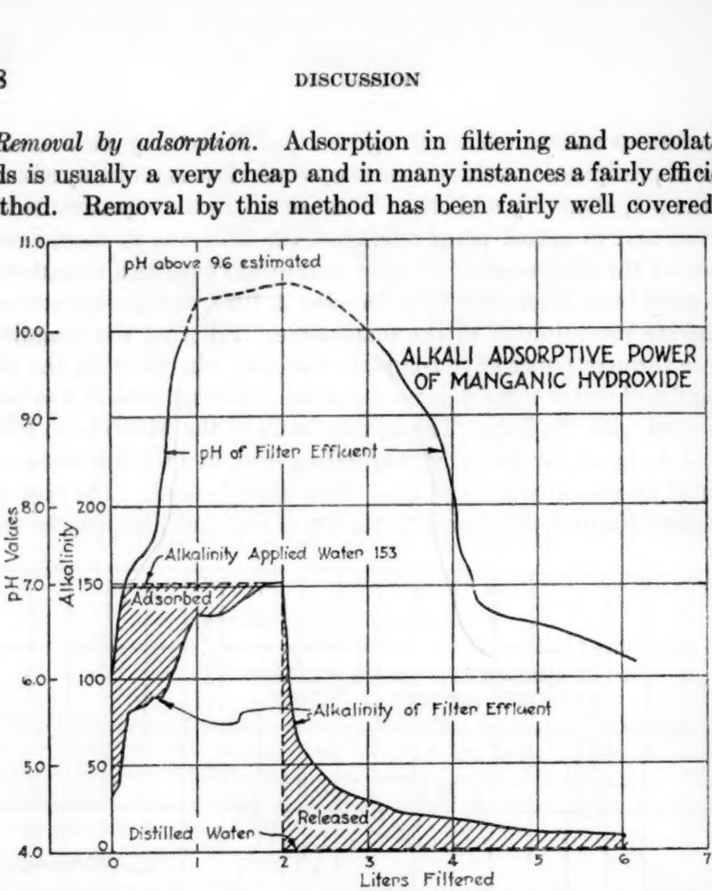


FIG. 12. VOLUME OF MANGANIC HYDROXIDE WHEN SATURATED WITH WATER ESTIMATED TO BE ABOUT 5 CC.

Clean silica sand was treated with manganese sulfate, potassium permanganate and sodium hydroxide until black coating was formed. Fifty-eight cubic centimeters of this sand, having an estimated volume of 5 cc. of manganic hydroxide, was placed in a laboratory filter and washed for several days by passing tap water through. After thoroughly washing with tap water, distilled water was passed through until there was no appreciable increase in alkalinity.

A solution of sodium carbonate was then filtered through at the rate of 2 gallons per square foot per minute.

After the alkalinity of the filtered water reached a point where it was the same as the applied water, distilled water was passed through at the same rate. Practically all absorbed alkali was recovered.

articles by Weston (17), Applebaum (18), Barbour (19) and Corson (8). The necessity of oxygen has led some to believe it is merely an oxidation process in which the soluble compounds are changed to the insoluble hydroxide. Corson believes that MnO_2 adsorbs the soluble

manganese, and gives up part of its oxygen to oxidise that adosorbed. Experiments confirm the fact that manganic hydroxide will adsorb the soluble manganese compounds, but the writer feels somewhat doubtful about the hydroxide being reduced to a compound of lower oxygen content. Reduction may take place under some conditions, but it is believed to be due to adsorbed acids.

Manganic hydroxide has remarkable adsorptive powers, which probably accounts for its power to remove the soluble compounds. Adsorption is defined by Falk (20) as being the difference in the composition of the surface layer at the contact of two phases and the composition of the main bodies of these phases. Figure 12 gives some idea of the alkali adsorptive power of manganic hydroxide. The curves indicate there is an equilibrium between the adsorbed alkali and the surrounding solution which depends on the alkalinity and pH. The adsorption or concentration of the alkali within the hydroxide rises rapidly as the pH increases. This is a very significant fact and may be the key to manganese removal by adsorption. The fact that it will adsorb the alkali from neutral salts such as sodium sulfate or chloride indicates that it has an affinity for certain, if not all, alkalies. By adsorbing both alkalies and the acid compounds of manganese, reactions are brought about that would not take place otherwise. The adsorptive powers of certain, if not all, gelatinous compounds, which are selective in their action, offers a vast field for future research. The commercial value of silica gel, a substance somewhat analogous to gelatinous compounds, is just beginning to be realized.

The activity of a surface, as explained by Langmuir (21), depends in general upon the nature of the arrangement and spacing of the atoms forming the surface layer. Hannan (22) gives an excellent presentation of microforces with reference to curvature and orientation, and calls attention to the fact that the water molecules adjoining a solid surface are oriented and for a stagnant layer. Without attempting to formulate a theory as to how the manganese is adsorbed, it seems well proven from experiments and the work of others that MnO_2, or higher oxides of manganese, have an attractive force for the soluble manganese. They seem to have the power of replacing or driving off the acid radicals. The curves in figure 12 indicate such a phenomenon when it seems that caustic alkali is apparently given off. Whatever be the nature of the reaction oxygen is required to complete the process; that is, to form the insoluble hydroxide. If oxygen is deficient the limit of adsorption may be the thickness of one, or a few molecules on the solid surface.

If sodium is adsorbed it will be exchanged for calcium somewhat similar to the action taking place in base exchange by the zeolites. There is no difficulty in producing water of zero hardness when sand from any of the filter beds is treated with sodium chloride, sulfate carbonate or hydroxide. The softening power lasts for only a short while unless the water is kept alkaline with sodium hydroxide or carbonate. Such a treatment probably could not be made to compete with the zeolites, but the fact that it has this power is interesting. Figure 13 shows how water may be softened when treated with sodium hydroxide and filtered through badly coated sand. This treatment

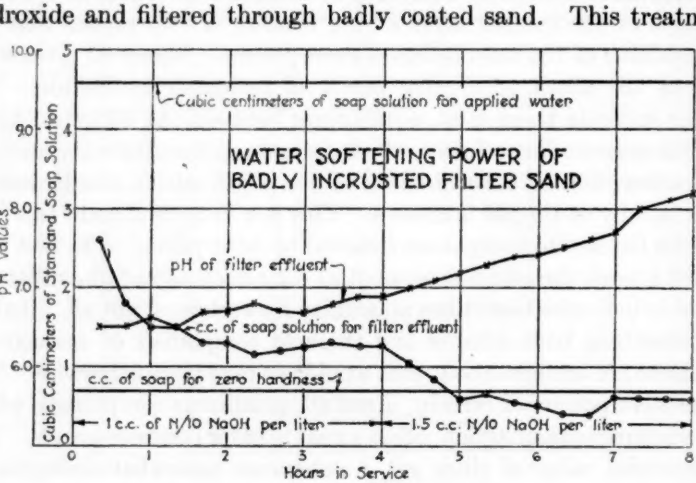


FIG. 13

Fourteen inches of sand from near the surface of Filter No. 19 placed in laboratory filter and water run through at the rate of 0.25-foot vertical drop per minute. Sodium hydroxide applied to laboratory tap water having a soap hardness of 54.3 p.p.m.

could not be continued indefinitely for the applied water must have a pH that will give points above the calcium carbonate equilibrium curve. Calcium carbonate will be deposited, and will probably stop up the pores in the hydroxide.

Manganese removal by adsorption in the filter beds. Removal by adsorption in the filter beds has not been very encouraging. Had there been no gelatinous coating around the sand grains, and had it been possible to aerate, better results may have been attained. As the dissolved oxygen was over 50 per cent saturation, except for a period of about 6 weeks, it is not believed that there would have been satisfactory removal by aeration under the conditions. Prechlorina-

tion probably would have prevented the bacterial growths, and with aeration may have given fairly satisfactory results. The sand in filter No. 21 was thoroughly washed with a Nichol's sand washing machine, and when put back into service chlorine at the rate of about 15 pounds per million gallons was added to the influent water. This was a very much higher dosage than could be used for the entire plant. The results were somewhat erratic at first and until the bed was drained dry for a few hours about once a week. After exposing to the air in this manner the manganese removal would be very good for five or six days, then there would be a gradual increase. The washing, and the high dosage of chlorine kept the sand grains fairly free from the slime coating. Yet with water containing from 6 to 8 p.p.m. of dissolved oxygen there would not be 50 per cent removal without occasionally draining the beds dry so as to expose to the air. No explanation can be offered as to why the aeration produced such a change in the adsorptive power of the beds, unless it allowed the adsorbed manganese to be changed to the hydroxide, which would give a free and increased surface area. The sand in the filter beds was being washed with a Nichol's sand washing machine at the time the manganese increased. Each bed was drained dry several days during the washing process. When thrown back into service there would be complete manganese removal and considerable reduction of alkalinity at first, then it would gradually increase until there was practically no reduction a week afterwards. The washing removed a great deal of the slime produced by the bacteria and allowed the sand to be exposed to the air for several days. Filter 25 was drained dry a few hours before washing each time washed. After a few days there was practically complete removal of manganese. The objections to such a procedure would be the necessity of about 50 per cent greater filtering area of the plant, and the enormous loss of sand with the foam when washing.

The addition of lime before filtration aided, but when alum is used as a coagulant the cost of treatment may be greatly increased. Experiments were conducted on a plant scale by adding lime to the water just before it goes to the filters. When enough lime was added to increase the pH above the calcium carbonate equilibrium curve fairly efficient reduction was obtained for a few days, but the sand grains soon became incrusted with lime and greatly reduced the adsorption. The incrustation around the sand grains obviates the necessity of accurate control of the application of lime in so far as it

pertains to the alkalinity and pH of the filtered water. If too much is applied for a few hours practically all the excess will be removed by adsorption, and if too little the incrustation gives up that adsorbed. With considerable hourly fluctuations of applied alkali the alkalinity and pH of the filter effluent will remain nearly constant.

Conclusions as to the most satisfactory methods of manganese removal. Manganese can be precipitated with ferric hydroxide in the iron and lime treatment. The fact that it is removed with the coagulant probably makes it the most satisfactory method. More study and the proper application of the physical forces will probably make iron and lime applicable to almost any water.

Most of the manganese may be removed by adsorption in filtering or percolating beds. Results confirm the previously published reports of others in that aeration, prechlorination, and the addition of an alkali before filtration increases the efficiency of this method.

The writer wishes to acknowledge the valuable suggestions and references to the literature on manganese given by Mr. Frank Hannan.

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OIL AND TASTES IN CHLORINATED WATER

Mr. W. R. Gelston:[4] For seven and one-half years, the water supply at Quincy, Illinois, had been sterilized with liquid chlorine with practically no complaints of tastes or odors which could be attributed to the chlorine treatment. The maximum average daily dose was 0.775 p.p.m. the maximum monthly average dose was 0.696 p.p.m.

In November, 1923, the chlorine absorbing capacity of the water seemed to be considerably reduced. The trouble lasted only a few days, but during that time there were many complaints, only one of which was of a serious nature.

A middle aged woman had become violently ill, one evening, a few minutes after drinking a glass of the water. She reported that she drank the water rather hastily and did not notice the disagreeable taste until she had drained the glass. She described the taste as being similar to iodoform. She called the attention of other members of the family to the unusual taste and they confirmed her statement. A doctor was called and the city water was duly found guilty of having caused the illness. The patient was

[4] Superintendent, Water Works Commission, Quincy, Ill.

confined to her bed for three or four days and seemed to be quite ill.

This trouble occurred at a time when the Mississippi River, the source of the supply, was at or near the low water mark. When the river gets below a stage of plus 1 foot, the 36 inch intake pipe in the main channel of the river, will not always deliver sufficient water. An additional supply is then secured through an old pipe which extends only a short distance into the river and which may, under certain conditions, deliver some water from Quincy Bay. Some water was being drawn through this old pipe when the trouble occurred.

Quincy Bay was formerly a part of the river and separated from the main channel only by islands. But government engineers closed the channels between the islands and converted a flowing stream into a two and one-half mile stretch of backwater from the river.

When the chlorine was causing trouble, an oily sheen was noted upon the surface of the water at the mouth of the bay and it appeared likely that phenol compounds were being drawn into the water supply through the old intake pipe.

Quincy Bay is used as a winter harbor for the storage of several steamboats and it was decided that the oil noted upon the water must have come from the steamboats. It was not until four months later that a better explanation for the source of the oil supply was found.

The daily papers reported the filing of a damage suit against the Electric Wheel Company by a farmer whose land was located upon the drainage area below the Electric Wheel Company plant. The papers filed in court by the farmer set forth that a concrete tank which was owned by the wheel company and used for the storage of fuel oil had developed a leak and permitted so much oil to escape into the creek that his livestock would not drink the water and that he was obliged to go to considerable expense to provide a new water supply.

Investigation of this clue revealed what was probably the real source of the oil which caused the trouble, if it was caused by oil.

On September 18, 1923, a carload of road oil was spread upon about one-half mile of unpaved streets in the vicinity of the Electric Wheel Company plant. This oil was purchased by the Wheel Company and some neighboring industries. The carload was more than was needed or desirable on the area treated; but it was all put on because it was necessary to get rid of it in some manner.

Heavy rains came just after the streets were oiled and most of the oil was washed down to Quincy Bay. The course it had to follow to reach the water works intake pipe consisted of about four miles of creek bed and about one and one-half miles of practically still water in Quincy Bay. After reaching the Bay it traveled very slowly and was probably still flowing out into the river in November when the trouble occurred.

This paper is submitted merely as an interesting experience. The doctor who found the water guilty of causing the woman's illness is inclined to condemn the water supply on very meagre circumstantial evidence and the cause of the illness is probably still a debatable question. If the trouble with odors and tastes in the water was due to the reaction of phenol products with the chlorine, the source of the phenol products is still a debatable question. If such products are contained in road oils, other water works men may find in this paper an explanation for similar troubles which they have experienced.

In conclusion the attention of the chemists should be directed to the real need for a simple indicator of the presence of phenol compounds in waters which are to be treated with liquid chlorine.

CAUSTIC SODA AND SODA ASH SOLUTIONS FOR FILTER SAND WASH

MR. FRANK W. GREEN:[5] A most important part of the operation of a rapid sand filtration plant is the keeping of the sand in proper condition to secure efficient filtration.

The introduction of chlorination into water purification has caused many places to increase the rate of filtration, thereby throwing a greater burden upon the washing devices. The beds become dirty in a shorter period of time than was formerly the case, so that the periodic removal of these accumulations has become of considerable importance.

Attention has also been given to improvements in the day by day washing methods, but in many cases no changes in this direction have been made. At Little Falls we have increased the velocity of the wash water somewhat, and have doubled the number of strainers along the sides and at the corners of the filters. This is not entirely effective, and in time the sand grains become coated with a greasy

[5] Superintendent, Filtration and Pumping, Montclair Water Company, Little Falls, New Jersey.

coating of organic matter which reduces the effectiveness of the sand bed.

The replacement of the old filtering material with new sand and gravel is too long and expensive a procedure to be considered if the material can be cleaned in place. Strong acids and also alkalies will remove the coating, but the use of the former is prohibited by the fact that they would attack the metal portions of the underdrains and strainer heads. Soda ash has been used for many years with but indifferent success.

Experiments in our laboratories showed that caustic soda would attack the coating, and that a mixture of not over three parts of soda ash to one part of caustic soda was also effective. In order to determine the proper amount of solution to use in a bed, the filter was washed, the surface coating of mud scraped off and several weighed portions of an average sample of the sand boiled with varying amounts of the mixed soda solution.

Our filter beds contain forty tons of filter sand and twelve tons of gravel. In most cases the application of 350 pounds of caustic soda and 1000 pounds of soda ash gave satisfactory results. In a few beds that were particularly dirty a slightly larger amount of the chemicals were used. The caustic soda and the soda ash were dissolved in separate tanks, and the solutions applied to the bed so that the liquid covered the surface of the sand to the depth of about an inch. The tank was then heated by means of live steam to just below the boiling point for a period of two days. After washing, the sand was as clean and sharp as when new; the organic material and any aluminum hydrate that may have been present had been entirely removed.

Other plants handling a colored water have reported equal success with this method.

RECONSTRUCTED SETTLING BASIN IMPROVES EFFICIENCY

Mr. C. R. Henderson:[6] The most interesting experience I have had in water treatment recently has been the building last fall of a division wall and weir in the settling basin at Davenport. This basin is irregular in plan, more or less rectangular, and holds 4 million gallons of water at a depth of about 12 feet.

[6] Manager, Davenport Water Company, Davenport, Iowa.

Currents existed between the inlet and the outlet and the basin could not be cleaned except when the condition of the raw water was favorable to filtration without prior sedimentation.

The new wall divided the basin into two nearly equal compartments, permitted cleaning of either compartment at any time and provided a perfect weir between the two compartments, each compartment holding about 2 million gallons. The quantity treated equals 5 million gallons per day. Before the division wall was built the average quantity of alumina used in November for thirteen years was 2.72 grains per gallon. The average for December was 2.30 g.p.g., for January 2.23 g.p.g., February 2.80 and March 3.72 g.p.g. Since building the wall, we have used in November 1.59 grain, December 1.49, January 1.24, February 1.68 and March 2.57 grains per gallon.

The raw or untreated water may vary more or less and there is always a chance that close watching may result in less coagulant being used over a short period, but it is our opinion that average conditions have prevailed, that the quantity of coagulant used has been sufficient and that the effluent of the settling basin has been of rather higher quality since the wall has been used than it was before.

The saving has been 1 grain per gallon in 5 million gallons per day and amounts to 715 pounds alumina per day (worth say $8.00), or nearly $3000.00 per annum.

The cost of the division wall and weir was $7700.00

SOME RECENT ADVANCES IN PURIFICATION AUXILIARIES

Mr. Charles P. Hoover:[7] I did not understand that I was to talk on any one particular subject as indicated by the Chairman, but that I was to tell about any interesting things of a water works nature that I have seen since the first of the year. I shall therefore tell you very briefly of some half dozen things that have interested me during the past year.

On my way to this Convention I stopped at South Pittsburgh and saw the most interesting softening plant I have ever seen any place. I am sure that the members of this section would be glad to have Mr. Trowbridge, Supervising Chemist of the plant tell us at our

[7] Chemist, Filtration Plant, Columbus, Ohio.

next meeting about the interesting chemical problems involved in the treatment of the South Pittsburgh water supply.

The plant belongs to the American Water and Electric Company and it is built in a deep ravine. The adaptation of the different units to the conditions there is really remarkable and if I had occasion to build a large water softening plant I think I should want to find a ravine to build it in.

I went from the plant to the laboratory and Mr. Roy Welter, the chemist in charge of the plant showed me a little laboratory agitator used in experimental work for mixing chemicals with water and the unique feature of it to me was that the driving mechanism was made out of the gears of an old water meter. This made its cost practically nothing and at the same time provides a device the speed of which can be accurately controlled.

This winter I visited the new Sacramento filtration plant designed by Mr. Charles Gilman Hyde and it is one of the really good looking plants in the country. The plant is provided with mechanical agitators which interested me very much and these agitators are driven by water engines. Water taken from a force main passed through the water engines driving the agitator mechanism and discharges from the engines into the wash water tank. It requires just about as much water to drive the mechanical agitators as is needed to wash the filters and therefore the cost of driving the agitators is reduced to a minimum.

I recently saw water pumped from a well at Miami Florida which had a color of 100 parts per million which I think is unusual.

The chairman has asked me to tell about the operation of the Dorr Clarifier which was installed at the water softening and purification plant at Newark, Ohio.

The Newark plant is built on a small river above the city and it was felt that the large amount of sludge resulting from the water softening-reactions, if retained in settling basins and discharged intermittently into the river, would create an unsightly condition. Therefore, a Dorr clarifier was installed in order to be able to discharge the sludge into the river continuously. The results of operation show that 95.4 per cent of the suspended solids are removed in the Dorr clarifier and that the discharge into the river is not noticeable. Other advantages of the clarifier are:

The period of retention in the settling basins is not being diminished each succeeding day by the accumulation of sludge. In other

words, the full capacity of the settling basins is available for sedimentation purposes instead of being storage reservoirs for sludge. It is possible to build this type of tank below the level of drains, that is if the sludge is pumped.

Carbonation. The presence of normal carbonates in lime softened water or rather the deposition of the carbonates on the filter sand, in the distribution system, meters and hot water lines, has been the principal objection to municipal water softening. Investigation toward working out a practical method of eliminating these difficulties were started at the Columbus Water Softening plant about five years ago and the first results of the experiments were published in the 1920, Annual Report of the Division of Water, Columbus, Ohio.

The first successful plant, that we know about, for carbonating a municipal water supply was built at the municipal water softening plant at Defiance, Ohio, in 1920 by Mr. Nicholas Hill (This JOURNAL, vol. 2, no. 2, March 1924).

The Newark, Ohio carbonation plant consists of a steam driven reciprocating, gas compressor, taking its suction through a dryer and scrubber from the breeching of the boilers and forces the scrubbed and dried gas through diffusers located in the settling basins near the outlet.

The operation of the plant indicates the water can be successfully carbonated by means of the flue gas, but there is one difficulty that must be overcome before the process can be regarded as entirely satisfactory. The hydrocarbons condense, forming tar-like deposits in the valves and heading of the air compressor. We hope to have this difficulty overcome in the near future.

PRECHLORINATION AT TORONTO

MR. N. J. HOWARD:[8] I should like to tell you briefly about our modified system of chlorine and alum treatment at Toronto during the past year. You will doubtless remember some two years ago, a paper which I presented upon a pre-chlorination process which we adopted in 1921. In order that your may better appreciate my remarks, it is necessary to describe again, as briefly as possible, the conditions under which the modified chemical system was first adopted, and the further modification which we made last year and which was used successfully throughout the year. The water at

[8] Bacteriologist in Charge, Filtration Plant Laboratory, Toronto, Ontario.

Toronto is derived from Lake Ontario, and is physically good for at least two-thirds of the days during the year. At other times, although not bad, it has a turbidity of 50 to 200 parts per million, and, as in many other cities, the degree of turbidity is naturally controlled by the meteorological conditions. The conditions we have to contend with is the period of turbidity, particularly in view of the fact that we have no sedimentation basins. Alum is added to the water which passes directly on to the filter, the whole process taking approximately twenty-eight minutes. We find, particularly in the summer months, that the water is subject to excessive pollution, the degree of which varies enormously and is controlled by the prevailing meteorological conditions. Sometimes in the morning, the laboratory figures, as judged by the free ammonia test, show the water to be chemically pure. The normal free ammonia content would be 0.002 part per million. Quite often, owing to inevitable conditions, this figure would rise in the afternoon to 0.20 part per million and show a heavy bacterial pollution. Now in order to treat this water, particularly in warm weather, it was necessary to apply big quantities of alumina—big quantities to us, but comparatively small to many other cities. The amount applied was 2½ grains per imperial gallon of alumina sulphate and at this time we were filtering between 40 and 50 imperial gallons per day. During the summer months, with the plant working up to capacity at a rate of 150 million gallons per acre per day, the addition of alum in that quantity placed a heavy load on the plant besides being extremely costly. We carried out experimental work, and found that we could eliminate alum at such times as the water was physically good, and substitute chlorine, which was applied immediately before filtration. As the plant is situated on the island and receives further chlorine treatment on the mainland, no attempt was made to sterilise the water. We put in an initial amount of chlorine so as to give a satisfactory purification and leave no residual chlorine in the filtered water, thus making the water suitable for final treatment on the city side, By doing this a saving of $35,000 was effected in operating costs.

In 1922 we found by practical experiment that the water could be successfully treated by using a smaller amount of alum with a modified system of treatment. When turbidity in the raw water ranged between 10 and 200 parts, we were able to reduce the quantity of alum, provided chlorine was applied at the same time, sufficient alum being added to clarify completely the water. Experiments

showed that, when chlorine was added in combination with alum, it was possible generally speaking to reduce the dose of alum to half a grain per gallon, and get a water physically and bacteriologically satisfactory. This has been the practice during the past year, using chlorine alone when the water was physically good, and chlorine and alum when the conditions made it necessary. Covering a period of three years we reduced the operating costs $148,000 and have been able to get the maximum quantity of water through the plant. We produced a physically good water, and bacteriologically better than when alum alone was being used. We have not advocated this method of operation elsewhere, and consider it is a question which has to be worked out locally, the whole situation depending entirely upon the quality of the particular water and system of purification involved.

At Cleveland, results indicated that this treatment of chlorine alone and the chlorine-alum combination did not work out. We feel, however, that our particular system of filtration which involves the drifting sand process is particularly suitable to this modified process. We have ten feet of sand in our filters, and due to the peculiar drifting sand system in which a portion of the sand is continually moving, we always have a minimum permanent layer of stationary sand of not less than 27 inches in depth. It is somewhat difficult to explain without seeing the plant which is decidedly complicated. Mr. Weston has successfully tried the chlorine-alum treatment with colored waters and has been able to reduce the color to some extent. So with waters of moderate turbidity and color, it seems a logical way to treat water, in order to secure a reduction in operating costs and at the same time get water acceptable from a sanitary standpoint.

SODA ASH FOR PREVENTING CORROSION AT CAMBRIDGE, MASS.

Mr. M. C. Whipple:[9] I shall say a few words about one of the problems of the Cambridge, Mass., plant. This plant was put into operation a year ago. It is one of the rapid sand type, equipped with coagulation basin and apparatus for the addition of alum and soda. After the plant had been in operation for a few weeks it became apparent that the most important subject for immediate study would

[9] Instructor in Sanitary Chemistry, Harvard University, Cambridge, Mass.

be the corrosive quality of the effluent. The raw water is typical of New England, having a color of 30 to 60 parts per million and an alkalinity of 10 to 20 parts.

During the first few weeks of operation we were troubled with iron deposits under cold water taps and greenish deposits under hot water taps where brass was used. The hydrogen ion concentration of the treated water was in the vicinity of pH 6.1 or 6.2, the carbon dioxide content 7 or 8 parts per million, and the alkalinity 5 parts.

In order to correct this condition it was not possible with the facilities at hand to add soda to the effluent water. If added to the raw water in necessary amounts to combat corrosion, coagulation was interfered with. Changes were made to allow the addition of soda to the filtered, aerated water as well as to the raw water.

With addition of soda to the effluent during the past four or five months a hydrogen ion concentration of pH 6.6 to 6.9 has been maintained. The carbon dioxide content has been reduced to about 4 parts per million and the alkalinity increased to 15 to 20 parts. The quantity of soda used has varied between 80 and 140 pounds per million gallons. This has increased the cost of purification, on the basis of \$1.70 per hundred for soda, by \$1.30 to \$2.30 per million gallons.

This seems, perhaps, a rather expensive method of combating corrosion. There are cheaper means of increasing alkalinity and reducing hydrogen ion concentration, lime treatment for instance, but we have used soda for several reasons. One is that the plant was equipped with apparatus for doing this. Another is that the hardness of Cambridge water is somewhat greater than that of other surface water supplies in that region, being 30 parts per million. It is looked upon as moderately hard. To use lime to combine with CO_2 and reduce hydrogen ion concentration would result in an increase of about 30 per cent in the hardness. This would be liable to bring forth complaint from the average consumer.

Another factor which led to continued use of soda was the experience with boilers. After the plant had been running about three months without soda treatment to the effluent observations upon the boilers at the pumping station led to the discovery that a very hard, compact crystalline scale was being formed in the tubes. This had a high degree of resistance to passage of heat and was unlike the soft, laminated scale formed with the raw water. The old scale was largely calcium carbonate, the new nearly pure calcium sulphate. It was

evident that the change would bring about boiler troubles that did not previously exist in the community. The difference in the character of the scale was due to the fact that alum treatment, without addition of soda, increased the sulphate or permanent hardness of the water about 100 per cent, from about 12 parts per million to 24 or 25 parts. On a percentage basis this represents a radical change in character from the standpoint of boiler operation. In using soda in necessary amounts to combat corrosion most of the increase in sulphate hardness was prevented.

I have kept close watch of corrosion in the city, and have developed a rough and ready test which measures increased corrosive quality and checks up the uniformity of treatment at the plant. At my house a cold water tap over a porcelain bowl has leaked consistently for several months at the rate of a drop a second. When the hydrogen ion value at the plant dropped below pH 6.7 or 6.6 for any length of time a distinct iron stain would appear on the bowl in twenty-four hours. No stain was apparent in the same length of time with a pH value of 6.8 or higher. Record was kept from day to day of the intensity of this stain and the observations compared with the plant record of hydrogen ion value. There was a high degree of correlation between them.

In cold weather it was found that a pH value of 6.8 to 7.0 held corrosion within very satisfactory limits. With rising temperature of the water in summer it is already evident that corrosion will increase and that it will be necessary to make the water more alkaline. This will not involve the addition of more soda (probably less will be used) for the raw water carries less CO_2 and has a higher pH value during the months when algae are growing.

Any relapse in addition of sufficient soda to the effluent of the plant has always been followed in the city by increased corrosion. This is noticeable in formation of stains and in the color of the water which has stood in contact with the pipes for several hours.

WATER-SOFTENING IN VIRGINIA BY IRON SULPHATE AND LIME

MR. L. H. ENSLOW:[10] At this time I should like to say something about a matter which I have not gotten very far with but hope to report on more fully at a later date. It is relative to water-softening.

[10] Assistant Sanitary Engineer, State Department of Health, Richmond, Virginia.

Water-softening is now a live subject in certain parts of Virginia as it should be everywhere where people have to use a hard water. With filtration progress we have done pretty well and now we have to push along softening also for certain sections. Heretofore we were very well satisfied when people did not have to drink bacteria or mud, but now there is a demand for softened water also and we are only too glad to help in the matter.

In the process of softening it would appear that the use of iron-sulfate is of considerable advantage or rather I should say it is with at least three or four different waters on which it has been tried.

In order to obtain information as to the best control of the softening process to be adopted at a new plant in Virginia I started a one man study, taking along my little field grip filled with chemical solutions and with the aid of a few Mason jars set up the laboratory.

Through the experimental work I established the fact that iron-sulfate solution has definite merits in softening. Having worked out the most satisfactory quantity of lime to apply when used alone and obtain the maximum economical softening with the least "after precipitation" or incrusting properties, I tried the effect of using a constant dose of iron and varying the lime.

Before the iron was tried knowledge of the use of alum as an agent to hasten the formation of the precipitate in softening led me to experiment with alum. It was found essential that not less than 1 grain be used. The results were satisfactory and a much quicker and larger grained precipitate—than from lime alone—could be had. The discouraging feature lay in the fact that when the filter effluent was tested for the presence of alum it was found that all except $\frac{1}{4}$ grain was in the filtered water. That is $\frac{3}{4}$ grain was passing the filter. This did not look encouraging from an economical point of view, even assuming that the folks did not object to drinking the $\frac{3}{4}$ grain. The next best bet sounded like iron-sulfate and from the experiments the use of it was apparently as satisfactory as alum and at the same time it was found that only $\frac{1}{2}$ of a grain was required to accomplish equally, if not better, results than was had from the alum.

The one important thing to be remembered in the application of iron is that it must be added just ahead of the lime and *not after it.* It does not appear that more than a half minute or so is necessary but it is essential that the mixing is quick and fairly thorough for the best results. In a gravity plant the iron may be applied at the inlet to the mixing chamber or just ahead of it and the lime held until the second

or third bay of the chamber. In plants with low lift pumps naturally it will enter at the suction side of pumps.

From my experience both in the Mason jars and in the plant I can tell you now that when ½ grain of ferrous sulfate is added to the water just prior to the lime a much superior precipitate is more quickly formed. It is more crystalline in appearance, settles very much more readily, leaves a much clearer sparkling water above. What little suspended precipitate goes into the filter does not choke it as rapidly as the water treated with lime only nor does it give the same incrustation either on the sand grains or in the mains, meters, etc., thereafter. I have data, figures and curves here to prove these statements but they are not now in shape for presentation. I hope later to say more about this feature of water softening and at that time will have more plant data to work on, since at present there are only two plants that have adopted it, but others will do so shortly.

What the exact rôle played by the iron or alum is I am not able to explain on a scientific basis. The precipitate when using iron does not appear under the microscope to possess any different crystal form from that of lime only. It was at first thought that the effect might be similar to that obtained through precipitating calcium in hot solutions by adding lime. In the latter case it is understood that the carbonate is formed as aragonite instead of calcite, as is the case in cold solutions. The only physical difference in the two precipitates noted is that where iron was used it is very nonuniform in particle sizes as compared with the uniformity of the straight lime precipitate. Contrary to expectation the iron is not uniformly distributed, but rather appears concentrated in widely separated crystals which are larger than the rest.

Samples of the filtered water representing the same dose of iron, but the lime varied over a considerable range, and a second set in which the lime dosages were the same but no iron was being added at the time of sampling were collected in large glass bottles and held for observation as to after precipitation, that is the property of incrustation and pipe coating. Those samples treated with lime only showed a very narrow range of treatment which could be called satisfactory and in every case the effluent was somewhat an incrusting one in the cold. The same was not true of those which had been iron-treated and the range of lime dosage which could be called satisfactory was appreciable.

From the results, therefore, it appears entirely practicable to utilize whatever extent or degree of softening that would appear to meet the particular requirements for a given supply and depend upon the iron to perform the functions which I have outlined.

In one particular installation the iron is invaluable. The supply is from a stream a short distance below the out-crop of several limestone springs. Normally the water is very hard and clear. Only sufficient lime is added to produce an effluent of 100 parts alkalinity-hardness. After heavy rains considerable turbidity appears and the hardness drops to less than 100 in the raw-water. At such times the iron dosage is raised to about two and at times as much as three grains per gallon and the lime reduced to obtain a normal carbonate alkalinity of but 20 to 30 parts. During such practice the plant is useful for turbidity removal primarily and the softening is a side issue. Prior to the advent of the iron treatment the plant could not handle the turbid water and produce a clear effluent and during the normal condition of the stream an optimum lime dosage had been essential to obtain a satisfactory precipitation in the basins.

It appears that the feature of greatest interest to the engineer when considering the value of iron-sulfate in softening is that its use will apparently allow for a smaller precipitation or coagulation basin or in other words by reducing the time to obtain the results which have required the relatively large basins and long period which in the past have been deemed necessary for the completion of reactions and precipitation.

It would appear that the mixing chamber or tank is by far the most important unit in the softening plant. Providing for the best obtainable mixing device and velocity through it will leave but comparatively little for the lime, the iron and the operator to worry about.

IRON REMOVAL PLANT AT GRIFFIN, GEORGIA

MR. E. S. CHASE:[11] An interesting treatment plant for the removal of iron from deep well waters was put into operation at a cotton bleachery in Griffin, Georgia in the spring of 1923. Prior to the design of the plant small-scale experiments were carried out and upon the results of these experiments the design of the plant was based in large measure.

[11] Sanitary Engineer, Metcalf & Eddy, Boston, Mass.

In the bleaching of white cotton goods it is very essential that the water supply used for washing be practically free from color and iron. The available water supply for the bleachery is from a series of deep wells containing iron in variable quantity. The experiments indicated that aeration, pre-filtration through coke and rapid sand filtration without the use of coagulant gave satisfactory results.

On the basis of the experimental evidence, a million gallon per day plant was designed, consisting of 2 units of coke pre-filters upon which the raw water was applied by spray nozzles, 2 units of settling basins and 4 units of rapid sand filters. The coke filters are contained in concrete tanks 9 feet by 33 feet by 9 feet superimposed over the preliminary settling basins. The filter media is 6 feet deep and consists of broken coke about 1 to 2 inches in size. In each unit there are 33 nozzles attached to lateral lines of distributing pipe. These nozzles are of brass and are similar to the sprinkler head of an ordinary garden watering can.

Each nozzle contains 21 holes, $\frac{5}{32}$ inch in diameter. The sprays, when the plant is in operation, rise about 2 feet in the air. The water falling and splashing over the surface of the coke becomes aerated to about 90 to 100 per cent saturation. Precipitation of the iron occurs on the surface of the coke medium and opportunity for deposition of iron sediment which may wash out from time to time from the coke is afforded by the settling basins.

These basins are each 9 feet 0 inch by 40 feet 0 inch by 8 feet 6 inches (water depth) inside dimensions with a capacity of 23,000 gallons, equivalent to approximately 1 hour storage with the plant operating at capacity. From the settling basins, the water flows to the rapid sand filters which are of the ordinary type. The filter media consists of 2.5 feet of fine sand with an effective size of 0.3 to 0.4 mm. and a uniformity coefficient of about 1.60. Under the sand is a 1.5 foot layer of graded gravel. The collecting system consists of a grid of wrought iron pipe. Rate controllers and loss of head curves are provided. Wash water is supplied at a rate of 24-inch. vertical rise per minute from a small elevated tank having a capacity of 18,000 gallons and 35-foot head to floor of filters. The nominal rate of filtration is 100 million gallons per acre per day.

The results obtained with the operation of the plant have substantiated the experimental evidence. The iron content of the raw water ranges from 0.2 to 2 p.p.m. which is reduced by the treatment plant to about a trace to 0.2 p.p.m.; the carbon dioxide content of the

raw water ranges from 10 to 30 p.p.m. and is reduced to about 2. p.p.m., thereby materially diminishing the corrosive qualities of the supply. The final effluent is clear and colorless and is giving entirely satisfactory results in the bleaching process. One man has charge of the operation of the plant and of the deep well pumps. The chemist of the bleachery makes frequent analyses of raw water and of the final effluent.

CHROMOGENIC ORGANISMS IN SWIMMING POOLS

Mr. T. D. L. Coffin:[12] At Bedford Hills, New York, there is a privately owned swimming pool some 60 feet in length and 20 feet in width which is supplied with spring water in volume sufficient to change the water in the pool about once in four days. This spring water is free from turbidity, color or iron, and in other respects is normal for the region. However, the owner of the pool has never found it satisfactory, for each season about ten days after filling the pool in early July, a decidedly red color develops in the water, and after a few days a brownish-red sediment appears upon the steps and pool bottom, the water retaining its reddish hue. This discoloration continues through out the summer, the pool being emptied usually in mid-September.

Some years ago, upon the advice of another, the owner treated the pool with copper sulfate in the usual manner without result, and last year called this case to the writer's attention. Samples of the water were taken to Mr. Luther R. Sawin of the Mt. Kisco Laboratory, who determined that the color was the result of the presence of Trachelomonas, an organism having a particularly resistant lorica, and one which is free from chlorophyll.

In the laboratory, samples of the water were treated with various strengths of copper sulphate up to a dose of 15 p.p.m. without results after an hour's standing in contact with the chemical. Samples were also treated with varying strengths of chlorine derived from chloride of lime and it was found that 50 p.p.m. of chlorine would remove the color from the water.

Later, in a small garden pool receiving the overflow from the swimming pool, the waters of which also have this reddish color, a practical test of the efficacy of chlorine was made and the laboratory find-

[12] Assistant Engineer, Bureau of Water Supply, New York City, Katonah, N. Y.

ing there was confirmed, although, as a bleaching powder itself was used, there was a milkiness in the water resulting from the lime present. The reddish tinge disappeared absolutely.

It is not known that this organism has ever been present in a potable water supply in sufficient numbers to occasion a reddish cast to the water, but the possibility exists, and it would appear that the remedy for its eradication must be other than the usual copper sulphate treatment and that the amount of chlorine required would make that method prohibitive for reasons other than cost alone.

Mr. G. R. Taylor:[13] Dr. Buswells' remarks recall an experience of the writer with a small private swimming pool. The pool was enclosed but had a glass roof which gave full sunlight on the pool. Salt was added in such quantities as to make the salt content considerably greater than sea water. This pool became infected with an algal growth which gave the water a brilliant green color. Copper sulphate in ordinary amounts failed to kill the growth, but it was finally removed by the dose of 100 parts to one million parts of water. A little later the artesian well supplying the family with water developed a peculiar sweetish taste, as they described it. Analysis showed the presence of chloride in large quantities indicating that salt water from the pool was reaching the well. It was the practice to flush the pool daily into the overflow drain which ran past the well at a distance of about 75 feet. Suspicion pointed to this drain, so a bag of salt was placed in the drain and water flushed through it. Within two hours the water in the well was too salty to drink. Investigation showed a break in the overflow pipe at a point about 100 feet from the well. As the well was over 300 feet deep with a considerable portion through rock there must have been a fissure leading directly through to the well.

[13] Chemist, The Scranton Gas and Water Co., Scranton, Pa.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Purification of Boiler Feed Water and Circulation Water. B. Alexandre. Chaleur et Industrie, Dec. 1922: Water and Water Eng., 25: 224, 1923. General paper, detailing among other processes, the recent German one by Balcke, termed "vaccination."—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Correctly Designed Swimming Pool. G. L. Lockhart. National School Building Journal, 5: 16, 1924. Constructional features and purification equipment for installation. 20 x 60 feet.—*Jack J. Hinman, Jr.*

The Feeding of Some Plankton Organisms. Dr. Marie Labour. Water and Water Eng., 25: 375–6, 1923. Jelly fish and the ctenophore, *Pleurobrachia pileus*, were observed to eat newly hatched fish.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Comparison between British and American Water Works Practice. George Mitchell. Water and Water Eng., 25: 462, (1923). Condensed and valuable comparison; especially remarkable, as author states he has no personal experience with American conditions.—*Jack J. Hinman, Jr.*

Geology of the Catskill Scheme, New York. H. J. F. Gourley. Water and Water Eng., 25: 443–449, (1923). A descriptive paper based largely on that by Berkey and Sanborn, entitled The Engineering Geology of the Catskill Scheme. *Cf.* this Journal, 10: 2, 328; 6, 1128.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Lessons of the War Water Supplies.—A. Sarmiento. Memoria de Ingenieros del Ejercito, May, 1923; Water and Water Eng., 25:3 92, 1923. Review of water supply work of German, French, American, and British armies.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Water Table in the Coastal Regions of Flanders. Dewevre. L'Eau, March, 1923; Water and Water Eng., 25: 226, 1923. Water found at varying depths in greensand is very high in Cl and unfit for drinking. Use made of wells which do not pierce clay stratum and hence supply the filtered water of the sand dunes.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The How and Why of Safety Valves. R. J. S. Pigott, G. S. Coffin and Editor. Power, **58**: 10, 357, September 4, 1923. General principles that underlie operation of the different types of valves are described, and probable causes of leakage discussed. Illustrations given of typical safety valves, with brief descriptions—*Aug. G. Nolte.*

The Operation of Hydro-Electric Stations. Ralph Brown. Power, **58**: 10, 363, September 4, 1923. How to obtain maximum output with minimum consumption of water from equipment available.—*Aug. G. Nolte.*

An Oil-Engine-Driven Ice Plant. Power, **58**: 10, 375, September 4, 1923. The construction and operation of the 50-ton Plant of the Red Bank, N. J., Pure Ice Manufacturing Co., is described.—*Aug. G. Nolte.*

Accurate Methods of Aligning Steam Turbines; Taking the Sag Out of a Tight Line. E. G. Barker. Power, **58**: 10, 379, September 4, 1923. A method quickly and positively applicable to any point in a tight line for producing the correct distance for vertical measurements of alignment.—*Aug. G. Nolte.*

Locating Brushes on the Neutral of Interpole Machines. B. A. Briggs. Power, **58**: 10, 381, September 4, 1923. Different methods of finding neutral point on commutator of interpole motors and generators; other factors that must be considered to locate brushes properly, also discussed.—*Aug. G. Nolte.*

How to Check Instrument Transformer and Meter Connections. V. H. Todd. Power, **58**: 11, 413, September 11, 1923.—*Aug. G. Nolte.*

Finding the Coefficient of Expansion and Compression on Indicator Diagrams. H. Schreck. Power, **58**: 11, 421, September 11, 1923.—*Aug. G. Nolte.*

Fuel Oil and Viscosity. M. G. Langham. Power, **58**: 11, 423, September 11, 1923. Practically any kind of fuel oil can be burned under a boiler provided it contains enough volatile material to ignite readily and is fluid enough to flow to burner. Sizes of pipe lines, pumps, heaters, and capacity of burners are dependent to great extent on viscosity of oil. Fuel oils vary widely in viscosity characteristics. To obtain maximum capacity, oil must be of right viscosity when it reaches burner. Oil burner manufacturers have realized this and one of the leading manufacturers recommends for his burners that viscosity of oil reaching atomizer be held at about 8 degree Engler, equivalent to 30.5 seconds Furol. Various grades of fuel oil must be heated to various temperatures to meet the specifications. Some grades would require no preheating. For maximum efficiency every precaution should be taken to maintain oil at correct viscosity. As viscosity may change during storage, it is desirable to take viscosity reading after oil has been in storage at temperature under which it is to be removed for use. Flash point of oil must be watched, in that, if temperature runs too high in storage tanks, there is possibility

of fire. Occasionally oil may be heated under pressure to prevent vaporization when heated above its flash point. Flash point is sometimes a limiting factor. Concludes that viscosity is important factor in handling of fuel oil and close attention to it would decrease annual waste of fuel oil and improve conditions of combustion.—*Aug. G. Nolte.*

Pumping Hot Water with the Aid of a Vacuum. H. W. Geare. Power, 58: 11, 427, September 11, 1923. Illustrated.—*Aug. G. Nolte.*

Pouring and Fitting Babbitt Linings. A. Hoyt Levy. Power, 58: 13, 484, September 25, 1923. Article tells of nature of babbitt metals, how to renew linings, bearing troubles and their causes.—*Aug. G. Nolte.*

Testing Resistance to Emulsification. Power, 58: 13, 493, September 25, 1923. The improved Herschel emulsifier is illustrated and its operation described.—*Aug. G. Nolte.*

The Storage of Bituminous Coal. Power, 58: 13, 513, September 25, 1923. From paper by W. L. Abbott read before annual convention of National Association of Stationary Engineers at Buffalo, September 13, 1923. Following items are discussed: (1) interest charges on investment during time coal is in storage; (2) cost of handling; (3) loss of value, due to degradation; (4) fire risk.—*Aug. G. Nolte.*

Furnace Setting for Oil-Fired Boilers. G. C. Adams. Power, 58: 14, 531, October 2, 1923. In design of furnace, lessening of losses by decreasing excess air entering furnace and distribution of fire evenly over entire surface of firebox are important points to be considered.—*Aug. G. Nolte.*

Burning Oil in a Stoker Furnace. A. A. Fette. Power, 58: 14, 535, October 2, 1923. During erection of New Iberia, La., plant of the Chas. Boldt Paper Mills, fuel oil was offered at rate that was attractive compared with coal, so it was decided to provide facilities for handling either coal or oil. Construction is illustrated and described.—*Aug. G. Nolte.*

Relation of Pressure and Velocity in Various Types of Steam Turbines. F. P. Hodgkinson. Power, 59: 12, 444, March 18, 1924.—*Aug. G. Nolte.*

Making a Power-Plant Heat Balance. T. Maynz. Power, 59: 12, 450, March 18, 1924. Equations and diagrams for computing various losses and obtaining heat balance for the power-plant.—*Aug. G. Nolte.*

Modifications of Tester for Oils. G. A. de Graaf. Power, 59: 12, 456, March 18, 1924. A modified "open cup" tester for flash and fire points is illustrated and described, which enables operator to obtain close checks on duplicate samples.—*Aug. G. Nolte.*

Fuel Oil or Coal for Steam Generation. F. H. Daniels. Power, 59: 12, 463, March 18, 1924. Extract of paper read before New England Wholesale Coal Association, February 13, at Boston, Mass. Conclusion is, that fuel oil cannot compete with coal for generation of steam in land plants, except for the short periods of time when overproduction gluts oil markets, or when strike conditions upset coal production. Fact that relative reserves of coal and oil are in ratio of 1370 to 1, makes it quite clear also the the short periods when oil has the advantage will in future become less and less frequent and of shorter duration.—*Aug. G. Nolte.*

Use and Abuse of Powdered Fuel for Stationary Boilers. J. E. Muhlfeld. Blast Furnace and Steel Plant, 10: 353–5, 1922. From Chem. Abst., 16: 3381, October 10, 1922. General review of factors which have retarded development of powdered fuel, with suggestions for further improvement. Combustion should be regulated so that ferric oxide is produced, rather than ferrous sulfide. Radiant heat effects of powdered fuel, owing to glowing particles and increased refractory surfaces, offer 20–30 per cent, as possible increase in obtainable thermal efficiencies.—*R. E. Thompson.*

Higher Steam Pressures or Pulverized Coal? F. A. Scheffler. J. Am. Inst. Elec. Eng., 41: 346–50, 1922. From Chem. Abst., 16: 3381, October 10, 1922. Comparisons are made of 100,000 Kw steam plants. It is shown that, with much lower capital cost, even better thermal plant efficiency will pertain with use of pulverized coal and lower steam pressure, than would be the case with higher steam pressure plant, stoker fired.—*R. E. Thompson.*

Keeping Down Furnace Losses. R. T. Haslam. Power, 55: 372–5, 1922. From Chem. Abst., 16: 3381, October 10, 1922. Certain amount of excess air is necessary for most economical boiler operation. Charts given, wherefrom correct amount excess air may be calculated, after analyzing flue gas with Orsat apparatus and determining stack temperature.—*R. E. Thompson.*

Imperfect Combustion and the Regulation of Firing. Haarmann. Feuerungstechnik, 10: 173–6, 1922. From Chem. Abst., 16: 3381. October 10, 1922. Every recorded percentage of carbon dioxide corresponds to two firing conditions, one in region of excess air, other in region of imperfect combustion. Heat loss much larger in latter case. Carbon dioxide recorders alone not sufficient, but must be accompanied by recorder for unburned gases.—*R. E. Thompson.*

Standard Methods of Testing Materials. F. Becker. Paper Trade J., 74: 15, 307 ff., 1922. From Chem. Abst., 16: 3392, October 10, 1922. Recommendations for analytical methods for aluminium sulfate, basicity or acidity of alum, and lime for causticizing.—*R. E. Thompson.*

Partition of Chlorine Between Water and a Gaseous Phase. W. S. Titov. Nachr. Physik.-chem. lab. Semsoinsés, 1917, 102–10. From Chem. Abst., 16: 3020, September 20, 1922. Partition of chlorine at 20 degrees between

water and air containing this gas is given by formula $(y - 1.748)^3 x^2 = (72.52)^3$, where x is volume of chlorine per thousand volumes of air and y the volume dissolved in water under corresponding partial pressure—e.g., when $x = 10$ parts per thousand, $y = 74.27$ under partial pressure of 7.6 mm.—*R. E. Thompson.*

Reactions of Caustic Soda with Aluminum Salts. EDOUARD GROBET. J. chim. phys., **19**: 331–5, 1922. From Chem. Abst., **16**: 3041, September 20, 1922. Conclusions of investigation in 1916 were: aluminum hydroxide is never precipitated pure, but is always contaminated with aluminate; aluminate is produced when 4 molecules of sodium hydroxide are present to 1 atom of aluminum; aluminate $Al(ONa)_3$ is formed by precipitating alum solutions. This work was repeated using concentrated solutions. Compounds formed on addition of sodium hydroxide to solutions of various aluminum salts are given. —*R. E. Thompson.*

Analysis of Lithia Water. D. BUTESCU. Bull. soc. chim. Romania, **4**: 26–34, 1922. From Chem. Abst., **16**: 3149, September 20, 1922. The water originated at source of the Tamaseu, Bihor, Transylvania.—*R. E. Thompson.*

Bacteriological Examination of Water. W. C. DE GRAAF. Tijdschr. vergelijk. Geneeskunde, **7**: 108–29, 1922. From Chem. Abst., **16**: 3149. September 20, 1922. Determination of number of bacteria per c.c. uncertain. Cultivation at 35 degrees for 3 days gives most constant results. Fermentation at 45 degrees, according to Eijkman, used for identifying bacteria of intestinal origin, this method being based on the fact that thermoresistant bacteria capable of fermenting glucose and characterized by positive methyl red reaction and negative Vosges-Proskauer reaction exist in the intestine. Only B. Coli will ferment glucose under conditions prescribed by Eijkman.—*R. E. Thompson.*

River Pollution from Milk Depots. WM. G. SAVAGE AND D. R. WOOD. J. State Med., **30**: 307–16, 1922. From Chem. Abst., **16**: 3149, September 20, 1922. Milk wastes are equivalent to approximately 150 times quantity of ordinary sewage and may create serious nuisance by discharge into water courses. Whey is more objectionable than washings containing milk, and is very difficult to treat. Simple storage, storage and chemical treatment, land treatment and biological methods were found unsatisfactory. Washings from floors, churns, etc., may be treated by ordinary biological processes.—*R. E. Thompson.*

Control of Steam Boiler Operation. GERMER. Industrie u. Technik, **22**: 3, 1922; Gas u. Wasserfach, **65**: 220–1, 1922. From Chem. Abst., **16**: 3150, September 20, 1922. Worm wheel and velocity type meters unsatisfactory for warm water, owing to error introduced by scale formation on delicate parts. "Volume" meters recommended, and for larger installations Venturi meters.—*R. E. Thompson.*

Modified Method for the Determination of the Hardness of Waters by Means of Soap Solutions. V. Crasu. Bul. Soc. Romana Stiin., **26**: 39–44, 1923. Chem. Ind., **43**: 16, B 310, April 18, 1924. Usual methods for determination of hardness of waters involve maintenance of soap solutions of exact strength, and necessitate strictly standardised experimental conditions. Author describes method whereby these disadvantages may be overcome without appreciable loss of accuracy. A solution containing 10–12 grams per litre of any suitable soap in 56 per cent alcohol is filtered after standing for 24 hrs., and standardised against a water of known hardness (prepared with calcium or barium chloride) in following way. Gradually increasing quantities of the standard hard water are placed in a series of similar test-tubes, and each portion is diluted to same volume with distilled water. Each portion is treated with same volume of soap solution, shaken, left for 15 minutes, vigorously shaken a certain number of times, and then left for 5 minutes, after which height of foam is measured. The hardness corresponding to a column of foam 1 cm. in height is thus determined. The determination of the hardness of any water is then carried out in exactly same way, by adding increasing amounts to a series of test-tubes, treating each portion precisely as in standardisation experiments, and thus determining amount of water required to produce a column of foam 1 cm. high, from which hardness can be calculated by simple proportion.—*A. M. Buswell.*

Water-Softening by Means of Doucil. T. P. Hilditch and H. J. Wheaton. Inst. Mech. Eng. and Chem. Eng. Group, 26.2.24; Engineering, **117**: 287–288, 1924; Chem. Ind. **43**: 16, B 310, April 18, 1924. The base-exchanging compound, doucil, or sodium alumino-silicate, resulting from interaction of dilute solution of sodium silicate (containing 2–4 mols of silica to 1 of soda) and dilute sodium aluminate, washed, and dried (cf. E. P. 177, 746; J., 1922, 372A) conforms closely when anhydrous to composition, Na_2O, Al_2O_3, $(SiO_2)_5$. Of the 13.3 per cent Na_2O present, 10.0 per cent is completely replaceable alternately by lime, and the lime in turn by soda. Complete replacement cannot, however, be effected with simultaneous production of completely softened water, and for practical purposes, particularly where water of zero hardness is required, calculations should be based upon exchangeable soda equivalent to 4 per cent of weight of anhydrous doucil present. To obtain high base-exchange capacity, the doucil should be used in plant designed so that all the material is evenly exposed to flow of water. In the manufacture, by careful adjustment of concentrations of aluminate and silicate solutions and of their respective soda contents, and by suitable mixing devices, a perfectly homogeneous gel of the alumino-silicate is prepared; the gel is transferred with as little disturbance as possible to a dryer and slowly dried over a period of 4–5 days, during which the water content is reduced from 90 to 50 per cent; the hard gel, in the form of lumps about 2 inches diameter, is then washed in a slow stream of distilled water, subjected to further drying treatment for about one day, and crushed to a convenient size. For use, material of $\frac{1}{8}$ to $\frac{1}{20}$ inch is the most suitable, and with adequate pipe arrangements for securing an even flow of water into and out of the container, with granules of this size a supporting bed of gravel or other inert material is not necessary. Granules $\frac{1}{20}$

to $\frac{1}{16}$ inche size, can be used for a top layer in a filter. Depth of bed may be largely a matter of convenience, but a bed 6 feet deep will soften to zero hardness a larger volume of water (15–20 per cent more) then two beds of the same area 3 feet deep. The salt consumption, in the regeneration, is much reduced by using the last portion of the brine from one regeneration as the first half of the brine for the next regeneration (cf. E. P. 203,497; J., 1923, 1094A). With this modification, salt consumption is about 8 lbs. per 1000 gals. of completely softened water of original hardness 20 pts. CaO per 100,000. The quantity of water used for salt solution (5 per cent brine), washing, and occasional back-flushing, is approximately 5 per cent of water softened. Time required for regeneration and washing is about an hour. On basis of exchangeable soda equivalent to 4 per cent of anhydrous doucil present, 1 ton of commercial doucil, containing 50 per cent of moisture, will soften to zero hardness, about 22,000 gallons of water containing hardness equivalent to 20 pts. CaO per 100,000 (25 grains, $CaCO_3$ per gallon), and for this purpose a plant capacity of about 64 cubic feet is necessary (35 lbs. of commercial doucil per cubic foot); a doucil bed 6 feet deep in a cylindrical shell, 3 feet 6 inches diameter by 8 feet high, with brine tank to hold 360 gallons will meet the requirements. Method is applicable for all ordinary and average waters, for supplies for laundry, dyeing, bleaching, and other works, and for boiler-feed water for steam pressures up to 120 pounds per square inch.—*A. M. Buswell.*

The Well-Water System of St. Petersburg, Florida. R. E. Ludwig. Amer. City, **30**: 497–9, 1924. St. Petersburg with a summer population of 20,000, and a winter population of 75,000, derives its water supply from wells which tap a honeycombed limestone lying 200 feet below the surface and overlaid by impervious flint stratum. Well water contains "Sulphur" (hydrogen sulfide gas) sufficient to give objectionable taste. Excessive drafts are apt to draw in salt and wells tapped below 200 feet are salty. Until 1921, air-lift pumping was used and gave a maximum yield of 2000 gallons per min. To meet rapidly increasing demand for water, new works have been installed, comprising 6 Layne and Bowler wells, aerating devices, and pressure pumps. Flexibility, to meet great variation in demand, and economy of operation were the factors in decision to replace air-lift by vertical turbine pumps. Layne pumps are set 60 feet below surface, at estimated ground water level, and are driven by A. C. motors direct-connected by vertical shaft and flexible coupling. Wells located in residential section are housed in attractive structures 10 x 10 feet in plan with tiled roof. Layne pumps discharge into two storage reservoirs or receiving basins, from which pressure pumps take suction. Aerator consists of vertical riser pipe surmounted by wooden cascade or step arrangement. Its use practically eliminates the hydrogen sulfide. Pump station of attractive design, with tiled roof, houses 4 motor-driven centrifugal pumps, of 1,500 gpm. capacity each, together with auxiliary equipment and chlorinating apparatus. Power is available either from municipal plant, or from utility company. Pumps arranged to operate in parallel or series to give normal pressure of 45 pounds or fire pressure of 90 pounds. In addition there are two

300 h.p. gasoline engines. One is connected with generator having sufficient capacity to drive the six well pumps; other is connected to 6,000 gpm. centrifugal pump taking suction from receiving well or from nearby lake formerly constituting supply. Tests showed power consumption of 0.42 k.w.h. per 1000 gals. on well pumps and 0.54 k.w.h. per 1000 gallons on pressure pumps; or a total of 0.96 k.w.h.—*W. Donaldson.*

Liability for Supplying Impure Water. A. L. H. Street. Amer. City, **30:** 506, 1924. Five decisions are cited where court has upheld liability for sickness on account of furnishing impure water, as follows: (1) New York Court of Appeals, Canavan vs. City of Mechanicville, 128 Northeastern Reporter, 882; (2) New York Court of Appeals, Stubbs vs. City of Rochester, 124 Northeastern Reporter, 137; (3) Minnesota Supreme Court, Keever vs. Mankato, 129 Northwestern Reporter, 158; (4) New Jersey, Jones vs. Mt. Holly Water Company, 93 Atlantic Reporter, 860, and (5) Wisconsin Supreme Court, Green vs. Ashland Water Company, 77 Northwestern Reporter, 722.—*W. Donaldson.*

Oil Burning Equipment in Wilmington Water Works. Anon. Amer. City, **30:** 514, 1924. Figures for oil burning equipment installed under two boilers at Wilmington, Del. in 1922 show that oil at 4 cents per gallon costs more than coal at $6.91 per ton. Relative costs for year were coal, $6.61, and oil, $7.58 per million gallons pumped.—*W. Donaldson.*

The Use of Iodine in Public Water Supplies. J. W. Ellms. Amer. City, **30:** 516–17, 1924. (From paper before Ohio Conference on Water Purification at Columbus). Clear and concise statement of problem, with special reference to Rochester practice of iodizing its water supply for prevention of goiter. Author believes treatment of the individual to be preferable to medication of entire water supply, on the grounds both of effectiveness and of cost.—*W. Donaldson.*

Do Your Meter Readers Read Meters? Anon. Amer. City, **30:** 533, 1924. Maywood, Ill., with 18,000 population, found that only 10 per cent of its meters were read correctly during past three years, resulting in estimated loss of $40,000. Too much dependence on one man.—*W. Donaldson.*

Underground Water Waste Detection Work in New York City. Fred B. Nelson. Municipal Engrs. Jour., **10:** 23–36, 1924. An assistant engineer of Dept. of Water Supply, Gas, and Electricity describes the water waste investigations from 1902 to date. Systematic study dates from 1910. Present organization consists of assistant-engineer-in-charge and field force including two assistant engineers, two rodmen, four caulkers, and 12 laborers, divided into four field parties with motor truck equipment. Aquaphones, pitometers, and wireless pipe locators are part of the equipment. Even the thermometer has been found useful in distinguishing between leaks from Croton and Catskill mains, or between city and ground water. Unique use of aquaphones was determining from boat soundings location of a leak in submarine main. For

pitometer work over 300 gaging stations have been established and calibrated. To date, special waste detection service has found and corrected underground leakage of 129 mgd. and it is considered that present water consumption of 700 m.g.d. would be 100 m.g.d. higher in absence of such a work. Leaks of ½ m.g.d. have been found without any surface indication and some leaks were detected which had existed 10 to 15 years. Estimated cost of waste detection has varied from $1.15 to $6.34 per million gallons saved, with 1922 cost of $3.62.—*W. Donaldson.*

The Control of Waste from Water Fixtures by House-to-House Inspection in New York City. Edward Neubling. Municipal Engrs. Jour., **10**: 37–51, 1924. Under present laws there is no authority for installing meters on private dwellings and only small portion of domestic consumption is metered. Estimated leakage from water fixtures, if unchecked for several years, is 20 per cent of total supply. Continuous house-to-house inspection has not been carried out, but since 1910 special inspections have been made from time to time on account of threatened water shortage. On account of intermittent nature of inspections, no permanent organization exists. Work is under direction of the Chief Inspector of Bureau of Register, who has under him a chief inspector for each borough. One house-to-house inspector can examine 8 buildings in a day, and it would require 120 inspectors to cover the city in a year. Inspection work is by squads of 12 men, each under a supervising inspector. One clerk is required for every five men in the field. Special forms are provided for recording inspection and notifying owner of wastage. Fine of $2.00 is imposed for failure to repair leaks. Author presents a formula for determining reduction in consumption under different conditions of inspection. Economical size of force is one which will cover city in two years. Such force in New York will cost about $4.50 per million gallons of water saved.—*W. Donaldson.*

The Graphitic Softening of Cast Iron. J. W. Shipley and I. R. McHaffie. Ind. Eng. Chem., **16**: **6**: 573, June, 1924. Dependent upon a frame-work structure of non-corrosive compounds formed in manufacture, namely, pearlite and cementite, which holds in place the graphite left after the iron has passed into solution and disappeared. Ferrite in contact with graphite easily loses iron into solution because of marked potential difference (0.56 V) between these substances. Pitting and graphitic softening occurred always in areas containing ferrite and graphite. Examination of unattacked areas showed graphite embedded in pearlite, with ferrite absent. White cast iron, in which ferrite is absent and all carbon in combination, corrodes little, if any. Wrought iron corrodes out of face, the metal becoming increasingly thin, there being no appreciable content of carbon, or other resistant compounds, to form a supporting structure. Micrographs reproduced show course of corrosion and structures which are left.—*Linn H. Enslow.*

Determination of Nitrate Nitrogen. F. M. Scales and A. P. Harrison. Ind. & Eng. Chem., **16**: 6, 571, June, 1924. Improved method, based on production of a rose color, when a reduced solution of strychnine sulfate is

added to solution containing nitrate ion in presence of excess sulfuric acid. *Advantages:* interference due to colored extracts practically eliminated: only a small quantity of unknown required: chlorides do not interfere: suitable in presence of most soluble organic matters. *Disadvantages:* reduced strychnine reagent only stable for a few hours: color intensity increases slowly in the dark, but fades in the light: presence of lead, zinc, or mercury, will interfere: great care required in preparing strychnine reagent.—*Linn H. Enslow.*

Making Lead-Lined Pipe. Chem. & Met. Eng., **30**: 9, 351–3, March 3, 1924. Lining of iron pipes with lead is done by 2 methods—cast, and tube-lined. Latter is more resistant to corrosion by acids. In manufacture of cast-lined pipe, the iron is first pickled and galvanized, for lead will not alloy directly with iron. The pipe is placed on an inclined rack with a mandrel inside at lower end, attached to a small pipe extending through the pipe to be lined. A quantity of molten lead is poured into the top of the feed pipe, which runs to the lower end. The pipe is then drawn through a quenching ring, concentric with the mandrel, where jets of water play upon the outside and solidify the lead. The hot lead above the quenching ring is kept fluid by a series of gas burners. Tube-lined pipes are made by expanding a lead tube into the iron pipe and sweating or soldering the two together. The pipes are heated from the outside while the expander is revolving. In lead-lined fittings cast iron cores are used and the whole submerged in molten lead.—*John R. Baylis.*

The Powers, Duties and Policies of the Sanitary Water Board. W. L. Stevenson. Pennsylvania W. W. Assn. 1923 Report. Page 27. "The Administrative Code," approved June 7th, 1923, created in Department of Health, the Sanitary Water Board, vested with jurisdiction over pollution of waters of State. Streams now relatively clean and pure shall be so maintained, and their cleanliness extended, excepting Mine Drainage. For streams now partially polluted, economics demand the inoffensive assimilation of a certain amount of polluting matter, under scientific method of disposal by dilution. Sanitary Water Board will confer privileges and impose obligations upon municipalities. Problem must be approached with recognition of financial aspects. For streams now highly polluted, it is no longer economical to restore them to purity.—*E. E. Bankson.*

Stream Pollution Problems. J. N. Chester. Pennsylvania W. W. Assn. 1923 Report. Page 52. True rule may be stated to be, that each riparian proprietor has right to have stream flow through, or pass, his land with its quality unimpaired and its quantity undiminished, except from a *reasonable* use of stream by riparian proprietors above him. **Domestic Pollution Problems Covered by Paper of W. L. Stevenson, 1924.** Mine Drainage Problem solution is indicated by court's decision in case of Mountain Water Supply Company et al. vs. Sagamore Coal Company et al., in part as follows: "The coal companies have brought nothing onto the land artifically." "The neutralization and softening, or other treatment, of the waters of Indian Creek will not entail an unreasonable burden upon the water companies." "The

drainage by the coal companies is a proper and natural use of their lands and constitutes a right of property." "The granting of an injunction against the coal companies would deprive them of their rights without due process of law." Mill and factory waste, including coke by-products, is an artificial use of land and, therefore, not in a legal class with coal mining operations.—*E. E. Bankson.*

Water Works from the Viewpoint of the Investor. W. R. VOORHIS. Pennsylvania W. W. Assn. 1923 Report. Page 69. The American Water Works & Electric Company has been offering preferred stocks of its subsidiary companies to consumers in territory served. Investments have ranged from $50,000, by one investor, to one share upon basis of $5.00 down and $5.00 per month. Service of waterworks is indispensable part of our daily life. It is a safe business in that its fundamental methods remain very much the same; no change in art, style, or mode, affects them. Investment is in property which endures for generations; which serves a continuous and increasing demand, is not much benefited by business booms, nor greatly affected by business panics; is not the field of exploiter, or of profiteer; but where reasonable service is awarded a just compensation.—*E. E. Bankson.*

Public Relations from a Newspaperman's Viewpoint. J. S. S. RICHARDSON. Pennsylvania W. W. Assn. 1923 report. Page 80. You have to overcome that fear which breeds suspicion, the suspicion which breeds hate, and the hate which breeds bitter controversy. This you can only do by coming out in the open, in the spirit of friendliness, and in a frank way telling the people your story, and especially teaching the youngsters who are coming along.—*E. E. Bankson.*

Public Relations from the Utilities Viewpoint. THEODORE J. GRAYSON. Pennsylvania W. W. Assn. 1923 Report. Page 95. It is basically untrue that any portion of the American people is fundamentally unfair. They are basically a fair race; but average politician is moral coward. We must devote ourselves to educating public as to the main points of public utility service. Some very successful experiences are related, all summarized in these words: "Do unto others as you would have them do unto you."—*E. E. Bankson.*

Public Relations from the Public Viewpoint. H. E. CARMACK. Pennsylvania W. W. Assn., 1923 Report. Page 118. Who is the public? Perhaps eighty per cent of your customers belong to the "silent public," the remaining twenty per cent being made up of the "knocking public," the "ignorant public," the "complaining public" and the "dishonest public." Show them how you run your plant. Put your cards on the table. Do not ask for any more than you are justly entitled to. Then you are on solid ground.—*E. E. Bankson.*

The Reasonableness and Equity of Service and Minimum Charges. MORRIS KNOWLES AND NATHAN B. JACOBS. Pennsylvania W. W. Assn. 1923 Report. Page 149. Theoretically, the design of a rate schedule is to apportion cost of

service between consumers upon basis of each individual's share toward cost of operating system. There is difference in opinion as to proper method. Minimum charge includes all the capacity, consumer, or readiness-to-serve, costs and a little more, namely, a certain quantity of water. Where the minimum is placed to include only 1000 to 2000 gallons per month, the general trend and direction of the rate can be worked out to be almost identical with that of the readiness-to-serve schedule. This leads to conclusion that, in most cases, minimum charge schedule when correctly designed is fair and equitable both to utility and to consumer. Service charge not being understood, it is better that there should be a minimum charge. Discussion by MR. CHESTER: There are states such as Ohio where Public Service Commission will not support service charge. The Public Service Commission in New York State said that minimum charge was illegal, that it discriminated; which service charge did not do. By MR. WALKER: It is now generally conceded that it is essential to make a substantial service charge in order to secure equitable rates for all. Suggestions and recommendations in favor of minimum charge are a step backward, rather than toward progress. Either service charge is right, or it is not right. If it is right, we should have no hesitancy in establishing our rate schedules accordingly. There is no question as to its merits as a definite, clear cut, and business-like proposition. It gets down to brass tacks and eliminates unsound bickering and dickering features of minimum. By MR. LEDOUX: Ready-to-serve charge is honest and logical method. Minimum charge recognizes same principle, but is subterfuge, as sop to consumer. By MR. BANKSON: "The plant capacity chargeable to demand cost (of service charge) is the surplus capacity of the system which represents the capacity required to meet unusual or spasmodic demands." Basis for stand-ready portion of service charge is "surplus portion of the plant and a portion of operation created by spasmodic demands." Theoretical and correct service charge for gravity plant would usually be noticeably less than for pumping plant.—*E. E. Bankson.*

The Construction of Rate Schedules. H. E. EHLERS. Pennsylvania W. W. Assn. 1923 Report. Page 191. First duty of public service company is to render adequate service, for which it is entitled to collect reasonable charges. Construction of schedule of rates must involve certain amount of compromise: is complex problem, calling for fullest cooperation of utility rate expert and local management, and for exercise of fully informed and experienced judgment. Two properties quite similar in general characteristics, size, and cost, may show widely different rate levels because of industrial load and consumers per mile of main. Rate requirements, or preference, can have no legitimate influence on cost analysis, which is a separate and distinct thing, subject to enough difficulties without unjustifiable influence of rate problems. Not all investment costs are attributable to "capacity" cost. For example, size of a storage reservoir is far more controlled by average, than by maximum demand. No property can be exactly proportioned in every item to the needs of the moment; some portions may have considerable margin, or reserve; other portions may be at their limit, or even deficient. Conclusions: (1) Importance of rate structure demands thorough study and analysis. (2) Results of cost

analysis do not constitute rate schedule, but rather a frame work, to be covered and rounded out by consideration of numerous other factors. (3) Cost analysis should be free from influence of and distortion by rate considerations. (4) Knowledge of characteristics of the service and of its operation, and of the development of the property is essential. (5) Decision as to form and proportions of rate schedules should be on basis of the particular local situation and its expected development.—*E. E. Bankson.*

Legislation of 1923. PHILIP P. WELLS. Pennsylvania W. W. Assn. 1923 Report. Page 218. Summary of revision and coordination effected by Administrative Code with reference to powers of Department of Forests and Waters, as a department, and to Water and Power Resources Board.—*E. E. Bankson.*

Decision of the Courts and Public Service Commission of Pennsylvania During the Year, Affecting Water Companies. EDGAR MUNSON. Pennsylvania W. W. Assn. 1923 Report. Page 230. (A) One Judicial tribunal shall exercise "independent judgment" upon the law and the facts, only when a question of confiscation is involved. (B) When consumer, without demand upon company, voluntarily lays his own service pipe, Commission cannot order company to make reparation for cost thereof. (C) Expenses before Commission amortized over period of three years. (D) Accrued Depreciation, not deducted from historical cost. (E) Free Service for right of way, and Free Service to Directors of Company held by Commission as "unfair, discriminatory, and economically unsound." (F) Regarding Extensions, Commission decided each case upon its own merits. (G) Regarding Mine Water Pollution, Court held that, unless there has been a legal condemnation of the waters of stream, and of rights of riparian owners therein, neither the Commonwealth, nor a company created for private purposes, has any right to enjoin upper riparian owners from lawful exercise of their riparian rights. (H) State tax on bonds is not allowed as operating expense; but Federal Income Tax is so allowed. (I) Contract Rates and Ordinance Rates are superseded by new tariff. (J) Valuation, for Rate Making Purposes, is the present fair value of property used and useful in the public service, including consideration of potential usefulness. (K) Review of other miscellaneous decisions.—*E. E. Bankson.*

Recent Federal Decisions. JOSEPH A. BECK. Pennsylvania W. W. Assn. 1923 Report. Page 270. Attempt made by Mr. Justice Brandeis, of the United States Supreme Court, in case of Galveston Electric Company vs. Galveston, 258 U. S. 388, decided April 10, 1922, to establish the prudent investment as determining factor in valuation of a public utility's property in a rate case, has not been supported by later decisions of U. S. Supreme Court, such as Southwestern Bell Telephone Case and Bluefield Water Case, where Courts held that present day costs must be given consideration and weight in fixing fair present value. Other lower courts have later followed this definition of the law.—*E. E. Bankson.*

Water Deactivation. F. N. Speller. Proceedings Eng. Soc. West. Penna. 39: 189, 6 July, 1923. In most waters, corrosion is proportional to free oxygen content. Describes briefly the development of means of control of corrosion by removal of free oxygen from water.—*E. E. Bankson.*

Algal Growths in Tank Waters and the Effect on Them of the Removal of the Dissolved Bicarbonates of the Water by the Addition of Sulphuric Acid. V. Gobinda Raju. Indian Journal of Medical Research, II: 4, 1057, April, 1924. An attempt to remove ignorance of algae types in India by study of their growth in tank waters. A temperature of about 75°F. appears to be most suitable for their growth. Growth was most abundant in shallow tanks, which had large amount of decomposing organic matter at bottom and sides. Experience in Bengal does not confirm the generally accepted notion that copper sulphate possesses marked algicidal properties. The experience was distinctly disappointing with this chemical. Use of lime, even in excess, was unsuccessful. Sulphuric acid, added in sufficient amount to neutralise all the bicarbonates present, renders water totally unfit for algal life. The forms present are killed and precipitated. The water need not be rendered acid. The treatment is based on the assumption that algae make use of CO_2 and bicarbonates for food purposes. The elimination of the latter removes source of food supply. Most common forms of algae found were species of oscillaria, anabena, cylindrospermum, navicula, euglena and spirogyra.—*Abel Wolman.*

Some Further Observations on the Species Method of Differentiating Fecal Organisms in Surface Waters in the Tropics. A. D. Stewart and V. Gobinda Raju. Indian Journal Medical Research, II: 4, 1157, April, 1924. Studies were made to check earlier observations and suggestions of Clemesha regarding variations in water organisms of varying origin. Findings indicate that B. Coli communis is about the commonest organism in recently polluted waters or crude human feces and at the same time the rarest fecal organism in waters which have been subject to prolonged storage. In freshly polluted water or crude human feces a large number of species is met with. In waters after prolonged storage only one or two species are encountered. This fact of altered ratios offers an added diagnostic index of degree of storage.—*Abel Wolman.*

Note on the Appearance of a Violet Producing Organism in Certain Water Supplies of the Madras Presidency. J. Cunningham and T. N. S. Raghavachari. Indian Journal Medical Research, II: 4, 1285, April, 1924. Sudden appearance of violet-producing bacteria in three water supplies is noted, although 16 years of observation of these supplies had not disclosed similar type. Tracing of origin was unsuccessful. Organisms are similar to B. violaceum, described by Lehmann and Neumann, but differ in that the three strains here isolated are gram negative and do not produce indol.—*Abel Wolman.*

Recent Developments in Sanitary Engineering. George W. Fuller. Can. Eng., 45: 18, October 1923. Paper presented in England at annual

meeting of Institution of Sanitary Engineers. Present U. S. status in purification of water and sewage disposal reviewed. Comparison of European and American methods of garbage and refuse disposal.—*N. J. Howard.*

Colorimetric Test for Sands. Abstract from Concrete Data for Engineers and Architects, Can. Eng., **45**: 19, November 1923. Important characteristics of sand for use in concrete are durability, cleanness, and grading. In particular, sand must be free of organic coating. Field test consists in shaking sand with dilute solution of sodium hydroxide, letting stand for 24 hours, and noting color of clear supernatant liquid. Washing greatly reduces organic impurities present in sand which are concluded to be generally responsible for defective qualities.—*N. J. Howard.*

Centrifugally-Cast Reinforced-Concrete Water Pipe. W. G. CHACE. Can. Eng. **45**: 20, November 1923. Description of outfit required for manufacture. Construction of reinforcing cage of steel wire, triangular mesh, for water pressure pipes is described. Account is also given of flexible joint provided for contraction.—*N. J. Howard.*

Turbines at Raanaafoss Power Station, County of Akershus, Norway. HALLGRIM THORESEN. Can. Eng. **45**: 25, December 1923. Excellent description of important hydro-electric development in Norway. Six turbines produce total output of 72,000 h.p. at 40 feet head and 107 r.p.m. with water consumption of 3200 cubic feet per second. Guaranteed efficiency of turbines was exceeded in each case.—*N. J. Howard.*

Effect of Alkali soils on Concrete Structures. G. M. WILLIAMS. Can. Eng. **45**: 25, December 1923. Article refers mainly to deterioration of concrete in irrigation works in alkaline soils in arid or semi-arid sections of the western states. Such soil contains large quantities of sodium, calcium and magnesium, originating from the natural weathering of the rocks. Ground waters in such localities contain considerable quantities of these salts in solution and are classed as alkali waters. Early investigations, as reported in bulletin No. 81 of Montana State Agricultural College, indicated that disintegration of cement by alkali salts was indirectly brought about by formation of new chemical compounds of greater bulk than the $Ca(OH)_2$ replaced which forced apart the particles of cement, thus destroying the bond. Summary of investigations by Bureau of Standards showed that the best quality of mortar or concrete may be disintegrated in sulphate soils and waters. Deterioration in chloride or carbonate waters appeared to be slow, or entirely absent. Rapidity of disintegration is proportional to sulphate content of water. Frost appears to accelerate. Carbonising of lime at surface of a structure will not prevent disintegration. Tar protective coatings are not permanent. Field investigations in Canada in the Prairie Provinces confirmed work of U. S. Bureau of Standards. $40,000 has been provided by Research Council of Canada for chemical research now being undertaken. Where sulphate concentrations permanently low, good quality concrete appears to have a life which fully justifies its use. Concentration of salt in ground waters may vary widely at

points but short distances apart. There appears also to be seasonal or yearly variation in some districts. Concrete of high quality is most resistant to action. Where alkali conditions are bad, factor of safety against failure can be greatly increased by employing proper drainage precautions. Portland cement, as now constituted, is inherently subject to attack by sulphates in soil and ground water; the practical and final solution of alkali-concrete problem is dependent upon discovery of some modification of, or addition to, portland cement, which will render it immune.—*N. J. Howard.*

Design of Surge Chambers. P. E. BAUMANN. Can. Eng., **46**: 8, February, 1924. Description of provision against excessive oscillation of water pressure. Means for determining variation of levels and equations are given.—*N. J. Howard.*

Status of Water Supplies in Quebec, 1923. T. J. LAFRENIERE. Can. Eng., **46**: 9, February 1924. During year, four filtration plants were started and two completed. Chlorination only is used in 22 towns. Sources of supply: 50.5 per cent from rivers, 10.5 per cent from lakes, and 39 per cent from springs and wells. Water purification is limited to river supplies of which 73.5 per cent are filtered, 11.5 per cent chlorinated and 15 per cent untreated. Typhoid mortality per 100,000 is slightly below 12, that of City of Montreal being 6.—*N. J. Howard.*

Mechanical Filtration Plant, Lauzon, Que. H. G. HUNTER. Can. Eng., **46**: 9, February 1924. Illustrated description of new plant at Lauzon.—*N. J. Howard.*

Water Motors Inject Chlorine at Moncton, N. B. J. VAN BENSCHOTEN. Can. Eng., **46**: 9, February, 1924. Illustrated description of hydraulic engines operating reciprocating pumps by which chlorine solution is forced into mains. Operation unaffected by interruption in power supply, but automatically ceases if discharge lines closed.—*N. J. Howard.*